THE FUTURE IS NOW

SCIENCE FOR ACHIEVING SUSTAINABLE DEVELOPMENT

GLOBAL SUSTAINABLE DEVELOPMENT REPORT 2019

Note

In the outcome document of the Rio+20 Conference, in 2012, entitled "The future we want", and again in "Transforming our world: the 2030 Agenda for Sustainable Development", in 2015, United Nations Member States decided that the High-Level Political Forum on Sustainable Development would be informed by the Global Sustainable Development Report. In the Ministerial Declaration of the 2016 Forum, Member States decided that the report would be produced quadrennially by an independent group of scientists appointed by the United Nations Secretary-General and comprising 15 experts representing a variety of backgrounds, scientific disciplines and institutions, with geographical and gender balance.

This report, *The Future is Now: Science for Achieving Sustainable Development*, is the first quadrennial *Global Sustainable Development Report* prepared by an independent group of scientists.

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Foreword

Foreword

Our world as we know it and the future we want are at risk.

Despite considerable efforts these past four years, we are not on track to achieve the Sustainable Development Goals by 2030. We must dramatically step up the pace of implementation as we enter a decisive decade for people and the planet. We must connect the dots across all that we do – as individuals, civic groups, corporations, municipalities and Member States of the United Nations – and truly embrace the principles of inclusion and sustainability.

Science is our great ally in the efforts to achieve the Goals. The Global Sustainable Development Report 2019, prepared by an independent group of scientists, presents an objective assessment of where we are falling short and what needs to be done. The Report highlights central entry points to leverage interlinkages and accelerate progress across all 17 Sustainable Development Goals.

This Report reminds us that the future is determined by what we do now and the window of opportunity is closing fast. I encourage all actors to translate the insights from this analysis into collective action.

Together, let us make the difficult choices that are necessary to realize our ambition and commit to accelerating progress towards achieving the Sustainable Development Goals.

António Guterres
Secretary-General

Preface

Preface

In 2015, United Nations Member States committed to the ambitious but achievable 2030 Agenda for Sustainable Development, charting a new path of balance for humanity and the planet.

Important steps have been taken, and innovative partnerships are taking shape. But if we are to achieve all of the Sustainable Development Goals, more needs to be done.

This Global Sustainable Development Report is a poignant reminder of the risks we face if we do not act swiftly and with purpose.

The Report makes clear that we are at risk of irreversibly degrading the natural systems that sustain us and further points out where we are off track in "leaving no one behind". More ambitious, more transformative and more integrated responses are urgently needed.

This evidence-based and action-oriented Report further highlights the indispensable role of science for ending hunger, tackling climate change, reducing inequality and accelerating progress across the Sustainable Development Goals.

The Global Sustainable Development Report complements the Secretary-General's annual Sustainable Development Goals progress report. It helps bridge the gap between knowledge and policy by synthesizing analysis and identifying evidence-driven pathways to transformation.

The Report rightly acknowledges that strengthening the science-policy interface and advancing the knowledge base to inform action require greater support and resources for scientific institutions.

Liu Zhenmin
Under-Secretary-General for
Economic and Social Affairs

Prologue

Prologue

Sustainable development has been the driving force in my political life for more than forty years.

I am as convinced today as I was as a young Environment Minister in Norway, in the early 1970s, that we will only secure a prosperous, peaceful and liveable planet if we harness economic growth and development to social solidarity across and between generations.

In 1983, I was charged by the General Assembly and the Secretary General of the United Nations to assemble and lead the World Commission on Environment and Development.

The Commission produced the ground-breaking report "Our Common Future", in 1987, which called for fundamental changes in our patterns of development so as to save humanity and the Earth from imminent disaster.

We called for "sustainable development", a pattern of development that meets the needs of present generations, without compromising the rights of future generations to fulfil their needs.

The report and its recommendations fed into the 1992 landmark Rio Summit. Two decades later, in 2012, there was finally enough support internationally for the essential efforts to start developing sustainable development goals.

Today, faced with the imperative of tackling climate change and responding to radical, fast-paced shifts in global technology, consumption and population patterns, there is growing consensus that sustainable development is the only way that we can avert environmental and social disaster.

The adoption of the Sustainable Development Goals in September 2015 was a key moment in defining that agenda and building a consensus for urgent, inclusive action.

The 2030 Agenda for Sustainable Development and the Paris Agreement on climate change that was adopted in the same year, are tangible proof of the benefits of multilateralism and the indispensable role that the United Nations can play to find global solutions to global challenges.

Their implementation offers a pathway to a world where poverty, inequality and conflict will not blight the life chances of millions of people who are currently denied the opportunity to enjoy their fundamental rights and freedoms.

But implementation requires States and all other relevant stakeholders from businesses and labour unions to civil society and academia to understand and engage with the scientific realities that underpin the relations between human activity and the natural world.

That is the critical contribution of this first quadrennial Global Sustainable Development Report, which is designed to be an evidence-based instrument that provides guidance on the state of global sustainable development from a scientific perspective.

As a medical doctor and a political leader, I have always placed the utmost importance on scientific evidence in formulating policies and measuring their impact.

By the same token, I have always believed that the development of science itself must be informed by humane values, and its awesome power must be applied in ways that respect human rights and share the benefits of progress in an equal and just fashion.

The present report is a clear and practical expression of the social and sustainable purpose of science. Most importantly, it emphasizes the need for a collective, holistic approach:

> "The true transformative potential of the 2030 Agenda can be realised through a systemic approach that helps identify and manage trade-offs while maximising co-benefits."

I hope that politicians and policymakers take note of the aims of the six key "entry points" identified in the report, where focused and collaborative action by various stakeholders can accelerate progress towards the Goals:

1. Strengthening human well-being and capabilities;
2. Shifting towards sustainable and just economies;
3. Building sustainable food systems and healthy nutrition patterns;
4. Achieving energy decarbonization and universal access to energy;
5. Promoting sustainable urban and peri-urban development;
6. Securing the global environmental commons.

In all of those areas, scientific expertise and innovation can be brought to bear and yield impressive results, but the determining factor will always be political will.

This is why the sort of research and consultation on display in this report needs to be complemented by sustained advocacy and campaigning in the public sphere, to both mobilize public support for the 2030 Agenda and use that support to hold leaders to their words.

In his famous study of human courage and cowardice entitled, "An Enemy of the People", the Norwegian dramatist Henrik Ibsen gave the following words to one of his characters:

> "A community is like a ship – everyone ought to be prepared to take the helm."

Our global ship is currently tossing and turning through stormy and dangerous waters.

But is anyone prepared to take the helm and steer a course that will bring us to safety, whatever hardships that may entail? And is anyone listening to the voice from the crow's nest, warning of fresh dangers on the horizon?

Or are we huddled below deck, either waiting for someone else to take the initiative or fooling ourselves that all is fine, that the waters will calm themselves of their own accord and there is no need to trim the sails or change course?

Each of us, from scientists and doctors to politicians and even playwrights, needs to be prepared to take the helm in an appropriate and realistic way – from our local community to national and international levels.

If we are prepared to do so, we will find that the Sustainable Development Goals themselves are the chart to see us through the storm.

The Sustainable Development Goals cover all aspects of human life and development – from health, education and the environment to peace, justice, security and equality.

Unlike the Millennium Development Goals, they apply to all countries and not just the developing world. That is important. Every Head of State, every Government and every citizen has a responsibility to ensure that the Sustainable Development Goals are met.

Instead of reducing international relations to business transactions and trade wars, the Goals are significant achievements that show the power of multilateral diplomacy and States coming together in their collective self-interest.

And crucially, the Goals and the work towards their implementation are not static.

As with the Paris Agreement, they are organic and evolving instruments that must increase momentum and ambition to be successful.

Much of that work is technical, scientific and highly specific. Without reliable and robust measurements, it will be impossible to judge whether sufficient progress is being made across the 169 indicators for the 17 Sustainable Development Goals, or for the 193 different nationally determined contributions of the signatories to the Paris Agreement.

Just as important, however, is continued political pressure to tackle the underlying causes of the problems the Goals seek to address, namely, poverty, discrimination, conflict and inequality.

If we do not put inequality at the heart of the global development agenda, we are doomed to failure.

We need courage to confront the vested political, business and economic interests that seek to maintain the current unequal order, and we need to grasp the opportunity that the move to a low carbon economy offers in order to rectify current inequalities.

We need to promote agreement, inclusivity and consensus to achieve policies that work for the common good, rather than narrow self-interest, across both the public and the private sectors.

And we need to inspire hope across all sections of society, especially among young people, letting them know that their voices will be heard, their experiences will be acknowledged and their ideas will be anchored in the policymaking process.

The data and the proposals in the present report are critical elements in society's armoury in the fight against climate change, poverty and injustice.

Ahead of the United Nations summits on Climate Action and on the Sustainable Development Goals in September this year, the report offers a practical guide to future progress on those key issues and an inescapable call to action.

Gro Harlem Brundtland
Former Prime Minister of Norway,
former Director-General of the World Health Organization
and member of The Elders, an international non-governmental organization founded by Nelson Mandela and comprising independent global leaders working together for peace, justice and human rights

Executive summary

Executive summary

Introduction

The present Global Sustainable Development Report was prepared following the decision of the United Nations Member States at the 2016 high-level political forum for sustainable development (HLPF) (see E/HLS/2016/1, annex IV, para. 7). The Report reflects the universal, indivisible and integrated nature of the 2030 Agenda for Sustainable Development. It also seeks to strengthen the science-policy interface as an evidence-based instrument to support policymakers and other stakeholders in the implementation of the 2030 Agenda across the social, economic and environmental dimensions of sustainable development.

The Global Sustainable Development Report is distinct from, and complementary to, the annual Sustainable Development Goals progress report prepared by the Secretary-General, which tracks progress across goals and targets using indicators from the global indicator framework. It does not produce new evidence; rather it capitalizes on existing knowledge across disciplines, through an "assessment of assessments". It highlights state-of-the-art knowledge for transformations towards sustainable development and identifies concrete areas where rapid, transformational change is possible. The Report is not only a product but also a process for advancing collaboration among actors in science, Government, the private sector and civil society in all regions of the world towards identifying and realizing concrete pathways for transformation driven by evidence.

The Report draws upon an extensive and diverse knowledge base, including numerous published articles in scholarly literature; and international assessments, like the Secretary-General's Sustainable Development Goals progress report (2019), the Global Environment Outlook 6 (GEO-6) regional assessments (2019), the Intergovernmental Panel on Climate Change (IPCC) special report (2018), the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) global assessment (2019), the International Labour Organization (ILO) and the Organization for Economic Cooperation and Development (OECD) reports on the future of work (2019) and others. It benefitted from five regional consultations with academic, policy, business and civil society communities; an extensive series of inputs received following an online call; a review by approximately one hundred experts coordinated by the International Science Council (ISC), the InterAcademy Partnership (IAP) and the World Federation of Engineering Organizations (WFEO); and comments on an earlier draft from United Nations Member States and accredited stakeholders.

The Global Sustainable Development Report was prepared by an independent group of scientists appointed by the Secretary-General, comprising 15 experts from various regions and representing a variety of scientific disciplines and institutions. The Group was supported by a task team comprising representatives from the United Nations Department of Economic and Social Affairs; the United Nations Educational, Scientific and Cultural Organization

(UNESCO); the United Nations Environment Programme (UNEP); the United Nations Development Programme (UNDP); the United Nations Conference on Trade and Development (UNCTAD) and the World Bank.

While benefiting from all inputs, the content of the report is the sole responsibility of the Independent Group of Scientists. The Group has addressed sustainable development as both a scientific and a normative concept, using it as a guide to analyse the problem and weigh the evidence, and, where needed, recommend policy-relevant solutions. For that purpose, the Report follows not just the letter but also the spirit of the 2030 Agenda, with the overarching goal of advancing human well-being in an equitable and just fashion, and ensuring that no one is left behind, while the natural systems that sustain us are safeguarded.

The Report uses the latest scientific assessments, evidence bases about good practices, and scenarios that link future trajectories to current actions to identify calls to action by a range of stakeholders that can accelerate progress towards achieving the Sustainable Development Goals. Those actions derive from knowledge about the interconnections across individual Goals and targets, recognizing that the true transformative potential of the 2030 Agenda can be realized only through a systemic approach that helps identify and manage trade-offs while maximizing co-benefits.

I. The transformative power of sustainable development

Since the adoption of the Sustainable Development Goals, there have been many positive developments. Countries have started to incorporate the Goals into national plans and strategies, and many have set up coordinating structures for coherent implementation. Of the 110 voluntary national reviews submitted during the 2016, 2017 and 2018 sessions of the high-level political forum, 35 mentioned explicit measures to link the Goals to their national budgets or were considering such action. There have also been initiatives aimed at safeguarding the environment, notably regarding climate change, land use and oceans. And important parts of the private sector have begun to move away from business-as-usual models, for example by adopting and reporting on sustainability standards. Meanwhile, the mobilization of civil society and non-governmental organizations in favour of sustainable development is rising.

However, despite the initial efforts, the world is not on track for achieving most of the 169 targets that comprise the Goals. The limited success in progress towards the Goals raises strong concerns and sounds the alarm for the international community. Much more needs to happen – and quickly – to bring about the transformative changes that are required: impeding policies should urgently be reversed or modified, and recent advances that holistically promote the Goals should be scaled up in an accelerated fashion.

Adding to the concern is the fact that recent trends along several dimensions with cross-cutting impacts across the entire 2030 Agenda are not even moving in the right direction. Four in particular fall into that category: rising inequalities, climate change, biodiversity loss and increasing amounts of waste from human activity that are overwhelming capacities to process them. Critically, recent analysis suggests that some of those negative trends presage a move towards the crossing of negative tipping points, which would lead to dramatic changes in the conditions of the Earth system in ways that are irreversible on time scales meaningful for society. Recent assessments show that, under current trends, the world's social and natural biophysical systems cannot support the aspirations for universal human well-being embedded in the Sustainable Development Goals.

Just over 10 years remain to achieve the 2030 Agenda, but no country is yet convincingly able to meet a set of basic human needs at a globally sustainable level of resource use. All are distant to varying degrees from the overarching target of balancing human well-being with a healthy environment. Each country must respond to its own conditions and priorities, while breaking away from current practices of growing first and cleaning up later. The universal transformation towards sustainable development in the next decade depends on the simultaneous achievement of country-specific innovative pathways.

Nevertheless, there is reason for hope. Human well-being need not depend on intensive resource use, nor need it exacerbate or entrench inequalities and deprivations. Scientific knowledge allows for the identification of critical pathways that break that pattern, and there are numerous examples from across the world that show that it is possible.

The science and practice of sustainable development thus points the way forward. Advancing the 2030 Agenda must involve an urgent and intentional transformation of socioenvironmental-economic systems, differentiated across countries but also adding up to the desired regional and global outcomes, to ensure human well-being, societal health and limited environmental impact. Achieving that transformation – a profound and intentional departure from business as usual – means carefully taking into account the

interactions between Goals and targets. Policymakers will find similarities and contradictions within them, as well as systemic interactions and cascade effects, as action towards one Goal can alter the possibilities for meeting other goals. A significant amount of knowledge is already available about those important interactions, and more research is under way.

An important key to action is to recognize that, while the present state of imbalance across the three dimensions of sustainable development arises from not having fully appreciated the interlinkages across them or having unduly prioritised the short-term, it is these same interlinkages that will lead to the desired transformative change when properly taken into account. The most efficient – or sometimes the only – way to make progress on a given target is to take advantage of positive synergies with other targets while resolving or ameliorating the negative trade-offs with yet others. Translating that insight into practical action for the Goals is informed in the Report by current assessments that emphasize the need for urgency, forward-looking expectations about a growing global population seeking higher levels of well-being and normative considerations, such as leaving no one behind.

Those actions can be undertaken by a more diverse group of people and organizations than governments of United Nations Member States alone. At the local, national and international levels, new key development actors are emerging and gaining greater power and influence. Innovative and powerful partnerships can result from collaborations between traditional stakeholders and emerging actors. The success of the 2030 Agenda thus depends on the cooperation of governments, institutions, agencies, the private sector and civil society across various sectors, locations, borders and levels.

II. Transformations for sustainable development

the present Global Sustainable Development Report identifies six entry points that offer the most promise for achieving the desired transformations at the necessary scale and speed. In doing so it takes into account the urgency, the forward-looking expectations about a growing global population seeking higher levels of well-being, and normative considerations, such as leaving no one behind, These are not entry points into individual or even clusters of Goals, but rather into the underlying systems. At the same time, not attending to the interlinkages that are intrinsic to these entry points, and cut across them – for example, through focusing on individual Goals and targets – would imperil progress across multiple elements of the 2030 Agenda. The selected entry points are:

- Human well-being and capabilities
- Sustainable and just economies
- Food systems and nutrition patterns
- Energy decarbonization with universal access
- Urban and peri-urban development
- Global environmental commons.

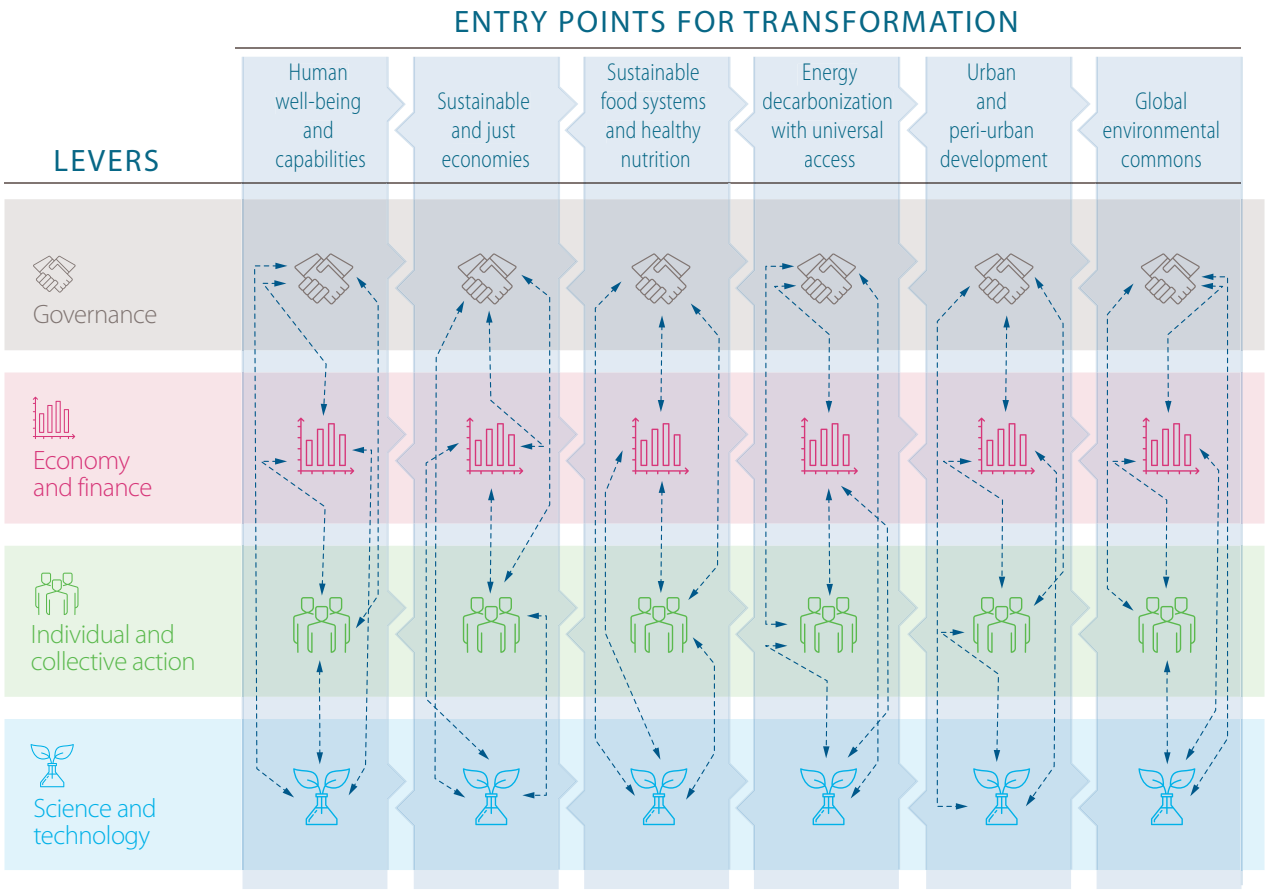
The Report also identifies four levers, which can be coherently deployed through each entry point to bring about the necessary transformations:

- Governance
- Economy and finance
- Individual and collective action
- Science and technology.

The levers are related to the means of implementation characterized in Goal 17, but are also different, in that they accommodate the multiple, complementary roles that individual actors and entities play in bringing about change. Each lever can contribute individually to systemic change; however, the present Report argues that it is only through their context-dependent combinations that it will be possible to bring about the transformations necessary for balancing across the dimensions of sustainable development and achieving the 2030 Agenda. As illustrated in the figure below, those combinations are integrative pathways to transformation, which underlie the call to action issued in the Report.

Decision makers need to act based on current knowledge and understanding of the linked human-social-environmental systems at all levels. That knowledge also needs to be more widely available to all countries and actors, motivating innovative coalitions and partnerships for success.

Moreover, new scientific and technological research, as well as the adaptation of existing knowledge and technologies to specific local and regional contexts, are needed to further streamline efforts, maximize synergies between the Goals and pre-emptively accommodate emerging challenges beyond the 2030 horizon. The present Report constitutes an innovation in the way scientific expertise is mobilized by the United Nations system as a whole. It proposes new ways of strengthening the contribution of science and technology to the 2030 Agenda, helping improve the science-policy interface.



III. Entry points and call to action for sustainable development

The strategies and call to action proposed in the Report for each of the six entry points for transformations, and for improving the role of science in implementing the Goals, are summarized below.

A. Human well-being and capabilities

Advancing human well-being – including material well-being, health, education, voice, access to a clean and safe environment and resilience – is at the core of transformations towards sustainable development. Not only is human well-being inherently important, but people's capabilities, in turn, drive global social, economic and environmental change according to sets of knowledge, skills, competencies, and psychological and physical abilities. Health and education are not just development outcomes. They are also the means of achieving key aspects of the global development agenda.

The world has made substantial advances in human well-being in recent decades, but extreme deprivations linger, and progress remains uneven. Extreme poverty – defined as living below the monetary threshold of $1.90 per person/day – was at 8.6 per cent of the world population in 2018, and is concentrated – with more than half the world's extreme poor living in five countries in sub-Saharan Africa and South Asia. In 2030, fragile States affected by crisis and conflict will be home to 85 per cent of those remaining in extreme poverty – some 342 million people.

Current estimates indicate that the world is not on track, without additional effort, to eradicate extreme poverty by 2030. Extreme poverty is now concentrated among marginalized groups – women, indigenous peoples, ethnic minorities, persons with disabilities and others. Gender inequality, which limits the opportunities and capabilities of half the world's population, further exacerbates the condition of women in poverty. In many places, there are socioeconomic gaps between persons with and persons without disabilities, because persons with disabilities often experience lower levels of education, higher rates of unemployment and economic inactivity, and a lack of social protection in comparison with their peers.

Income poverty, poor health, low levels of education, lack of access to water and sanitation and other deprivations tend to overlap. Households and individuals often suffer multiple forms of poverty. In 2015, the number of people living in extreme poverty

had fallen to 736 million. But the multidimensional poverty index calculated in 2018 for 105 countries presented a more sobering picture, indicating that 1.3 billion people live in households with overlapping deprivations. There is also clear evidence that multidimensional poverty has been falling more slowly than income poverty. National, regional and local authorities and communities should focus on reducing gaps in opportunities and basic rights among social groups that are most at risk of being left behind in their own territories.

In addition, nearly 1 billion people live on $2 to $3 per person/day, barely above the extreme poverty threshold of $1.90. Those who have just moved out of extreme poverty, and the 4 billion people who do not have any form of social protection, remain highly vulnerable to economic and environmental crises, climate change, armed conflicts and other shocks that threaten to push them into extreme poverty. Action must be taken to eliminate deprivations and build resilience, especially through targeted interventions where poverty and vulnerability are concentrated, or billions of people are at risk of being left behind.

Eradicating poverty, advancing gender equality and reducing other forms of inequality are closely interrelated objectives and require expanding interventions and measures far beyond the monetary thresholds of extreme deprivations to address the multidimensional and overlapping nature of poverty. Economic growth alone cannot achieve that. Deprivations and inequalities exist in education, health care, access to clean water and energy, access to sanitation services, exposure to infectious diseases and many other critical dimensions of well-being.

Quality social services, such as health and education, and protection against natural hazards, including disaster risk reduction, should be available to everyone. Legal and social discrimination against marginalized people should be eliminated, including barriers that limit access by women and girls. This is critical for realizing human rights for all people and respecting human dignity.

Furthering human well-being and protecting the Earth's resources require expanding human capabilities far beyond the thresholds of extreme poverty, whether based on income or other basic needs, so that people are empowered and equipped to bring about change. Investment in early childhood development, access to high-quality education, higher enrolment in science, technology, engineering and mathematics (STEM) programmes – especially for girls – expansion of healthy years of life, and attention to mental health and non-communicable diseases can improve lifelong chances for individuals and are cost-effective means of accelerating sustainable development.

Effective action in any of those areas requires acknowledging and addressing the links among them – the close ties between climate change and human health, for instance, or the ways in which biodiversity loss and deterioration of ecosystem services exacerbate inequalities. Pathways to advance human well-being ultimately require cooperation, collaboration and dialogue among multiple actors, and employing many levers of change. There is no single pathway, and different combinations of efforts are required across regions and for countries in special situations.

Call to action

- All stakeholders should contribute to eliminating deprivations and building resilience across multiple dimensions through universal provision of and access to quality basic services (health, education, water, sanitation, energy, disaster risk management, information and communication technology, adequate housing and social protection), that are universally accessible with targeted attention where poverty and vulnerability are concentrated and with special attention to individuals who are most likely to be left behind – women and girls, persons with disabilities, indigenous peoples and others.

- Governments should ensure equal access to opportunities, end legal and social discrimination and invest in building human capabilities so that all people are empowered and equipped to shape their lives and bring about collective change.

B. Sustainable and just economies

Economic growth has increased national incomes significantly, albeit unevenly, across countries. While that has contributed to advances in human, social and economic well-being, the effects on human societies and the environment are currently unsustainable. Economic activity should be seen not as an end in itself, but rather as a means for sustainably advancing human capabilities. Decoupling the benefits of economic activity from its costs at all levels is essential in itself and can also support the systemic transformations envisaged through the other five entry points advocated in this Report. Such an outcome would greatly accelerate the necessary reconfiguration and help to put people, societies and nature on the path to sustainable development.

Currently, there are numerous reasons why that is not happening. One oft-cited reason is the use of the gross domestic product (GDP) – the market value of goods and services produced over a year – as the sole

or predominant metric for guiding economic policy for human development. While reforming policymaking at this level is essential, it may not happen rapidly enough across the world to guarantee effective pathways towards sustainable development.

On the other hand, several other significant impediments could be addressed, even in the very short term. Production valuations do not account for all costs or value added, since prices charged for goods and services do not reflect the full costs of negative externalities, such as waste generated and released into the environment. Continually increasing the consumption of waste-generating goods and services globally is unsustainable. On current trends, annual global resource use is projected to reach over 18 tons per capita by 2060, with unsustainable impacts from increases in greenhouse gas emissions, industrial water withdrawals and agricultural land area. Examining the life cycles of specific items, such as plastics and electronics, leads to similar conclusions. Indeed, social and economic deprivations in many parts of the world can be addressed only through increasing consumption, but that needs to be balanced by shifting consumption globally towards goods and services produced with much lower environmental impact.

Investment in the Sustainable Development Goals from all sources is significantly short of what is needed. Production across national jurisdictions also leads to its own set of challenges. While globalization has contributed to reducing poverty, generating jobs, enabling greater access to a wider range of products and sparking innovation, the distribution of production across different national jurisdictions can also result in a race to the bottom in terms of environmental and labour standards. Nationally determined instruments, such as regulations or taxes, may not be adequate to manage those effects.

In recent times, economic growth has also been deeply unequal. There has been an unprecedented increase in wealth and income disparities in many countries, primarily driven by concentration at the top, with the share of the richest 1 per cent of the world population reaching about 33 per cent of total wealth on the planet, in 2017. For the lowest quarter of the distribution, the share was only about 10 per cent. For individuals caught between those two extremes – primarily the middle classes in Western Europe and the United States of America –, the period was marked by – at best – sluggish income growth. Concerns remain that increasing automation, including the work performed by skilled workers, may lead to worsening outcomes for many, with increasing inequalities and ever greater concentration of wealth and power. In addition, labour market inequalities between women and men limit the advancement of gender equality and the empowerment of women. Income, wealth and gender inequalities often translate into inequalities in opportunity through unequal access to quality childhood nutrition, education, health care or societal discrimination, and they limit intergenerational mobility. Indeed, inequalities can become self-perpetuating, through inherited wealth or exclusive access to high-quality education and skills.

There is now consensus – based on robust empirical evidence – that high levels of inequalities not only raise difficult issues for social justice, but also lower long-term economic growth and make such growth more fragile. Inequalities also tend to become entrenched through the efforts of those at the very top to secure and perpetuate their positions through various channels, such as having a greater say in the political process or weakening anti-trust and other regulatory efforts that are aimed at curbing monopoly power and improving market efficiency.

Perpetuating current modes of production and consumption, and current levels of inequality threaten the achievement of the entire 2030 Agenda. Urgent transitioning away from patterns of economic growth, production and consumption that perpetuate deprivations, generate inequalities, deplete the global environmental commons and threaten irreversible damage is needed. Transitioning towards long-term decarbonized and sustainable development that maximizes positive human impacts, equalizes opportunities among social groups and women and men, and minimizes environmental degradation is essential.

A significant part of the transformation will come from changing volumes and patterns of investment – both public and private. Estimates of the magnitude of the investment needed vary, but are generally of the order of trillions of dollars annually. Increasing the volume of investments and redirecting them towards sustainable development will be key: national and international financial systems must be aligned with the Goals. Investments from development finance institutions, official development assistance (ODA) in keeping with international commitments and domestic public budgets at national and local levels can help to crowd in investments from the private sector. At the same time, all flows must be made consistent with sustainable development pathways through means that are ambitious, transparent and accurate. An agreed upon sustainable development investment label could help channel capital flows towards assets that contribute to sustainable development.

Call to action

- Governments, international organizations and the private sector should work to encourage investment that is more strongly aligned to longer-term sustainability pathways and to facilitate disinvestment away from pathways that are less sustainable.
- All stakeholders should work together to achieve a global decoupling of GDP growth from the overuse of environmental resources, with different starting points that require different approaches across rich, middle-income and poor countries.
- Governments, supported by civil society and the private sector, should promote an upward convergence in living standards and opportunities, accompanied by reduced inequalities in wealth and income, within and across countries.

C. Food systems and nutrition patterns

Food is essential to human survival, and its provision employs over 1 billion people. The global food system comprises many local and regional food systems. It includes not only food production but also all food-related activities and how those activities interact with the Earth's natural resources and processes. Because of its climate and environmental impacts and shortcomings in healthy, safe nutrition for all, today's global food system is unsustainable. Moreover, it does not guarantee healthy food patterns for the world's population. It is estimated that more than 820 million people are still hungry. At the same time, rising obesity and overweight can be seen in almost every region of the world. Globally, 2 billion adults are overweight, as are 40 million children under 5 years of age.

Billions of hectares of land have already been degraded, and an additional 12 million hectares of agricultural land are likely to become unusable for food production every year. Furthermore, agricultural practices can lead to eutrophication of the aquatic environment, groundwater contamination, soil acidification and atmospheric pollution. Those practices were also responsible for 60 per cent of the global emissions of the greenhouse gas nitrous oxide (N_2O) in 2011. However, the share of N_2O from agriculture seems to be decreasing. When all emissions associated with the global food system are considered, they account for more than 19 to 29 per cent of total greenhouse gas emissions. Without technological improvements or other forms of mitigation, especially the restoration of soil health in order to increase its carbon content, greenhouse gas emissions from global agriculture could rise by as much as 87 per cent if production is simply increased to meet the demands of the global population in 2050. That scenario is incompatible with the Paris Agreement and the Sustainable Development Agenda.

Another concern is fluctuating food prices and asymmetric contractual and trade agreements, which handicap the world's 750 million smallholder farmers in developing countries and affect the poorer households, which spend a high proportion of their income on food. Moreover, although there are many economic actors in the global food market, many of its components are controlled by a relatively small number of actors. Concentration runs the risk of reducing the resilience of the global food system by generating uniformity in industrial agricultural practices.

Scaling up the food system as it exists today to feed a growing global population through 2050 and beyond, while accommodating non-food agricultural commodities is an overarching concern. However, under business-as-usual scenarios, an estimated 637 million people will be undernourished, and the environmental impacts of increased production would eliminate any chance of achieving the Goals of the 2030 Agenda. In addition, pests and crop diseases put global food supplies at risk; but managing them with increased use of chemical inputs could jeopardize many environment-related Goals.

Thus, business-as-usual pathways and upscaling current practices are not options if the global food system is to sustainably and equitably meet the needs of the global population in the future. Fortunately, however, the challenge of transitioning food systems onto a sustainable trajectory is not insurmountable. Recent studies describe food systems that are capable of delivering nutritious food for a global population of 9 to 10 billion with greatly reduced environmental impacts. Transitioning to sustainable food systems requires technological innovation, strategic use of economic incentives, new forms of governance and value and behavioural changes.

Because the quantity, quality and price of agricultural goods produced by worldwide plant production systems remain heavily dependent on chemical fertilization and the control of pests and weeds, technological innovations in food production methods are prerequisites for transitioning towards environment-friendly and healthy production systems. However, technologies alone cannot deliver the transition. Policy and institutional and cultural changes are needed to enable more equitable global access to nutritional foods and to promote agroecological practices that are deeply rooted in local and indigenous cultures and knowledge, and based on small- and medium-scale farms that have temporal and spatial

diversification and locally adapted varieties and breeds that can be strongly resistant to environmental stress. Agroecology has proven successful in helping farmers overcome the effects of degraded soil and poor weather in many developing countries.

In transitioning towards sustainable food systems, the focus must be on enabling more equitable global access to nutritional foods and maximizing the nutritional value of produce while, at the same time, minimizing the climate and environmental impacts of production. The actions of all four levers that can transform the food system vary from region to region and there are clearly many viable pathways. As prescribed in Goal 17, it will take a combination of different tools, actors and solutions adapted to diverse contexts to achieve transformation of the food system.

Call to action

- All stakeholders should work to make substantial changes to existing infrastructure, policies, regulations, norms, and preferences so as to transition towards food and nutrition systems that foster universal good health and eliminate malnutrition while minimizing environmental impact.
- Countries must take the responsibility for the entire value chain related to their food consumption so as to improve quality, build resilience and reduce environmental impact, with developed countries supporting sustainable agricultural growth in developing countries.

D. Energy decarbonization with universal access

Access to energy is universally recognized as key to economic development and to the realization of human and social well-being. Energy poverty remains extensive, with close to 1 billion people without access to electricity – predominantly in sub-Saharan Africa – and more than 3 billion people relying on polluting solid fuels for cooking, which causes an estimated 3.8 million premature deaths each year, according to the World Health Organization (WHO). In many regions, the current use of biomass fuels requires women and children to spend many hours per week collecting and carrying traditional biomass that is burned in highly inefficient and polluting stoves. Yet, electricity generation, heat production and transport rely heavily on fossil fuels and together account for roughly 70 per cent of global greenhouse gas emissions, including 40 per cent from electricity. The fastest progress in renewables continues to be in electricity generation, where close to 25 per cent came from renewables in 2016, thanks to the rapid expansion of solar photovoltaics (PV) and wind. The use of modern renewables for heat and transport remains limited, with shares of 9 per cent and 3.3 per cent, respectively. Considering that heat and transport represent 80 per cent of total final energy consumption, particular efforts are needed in those areas to accelerate the uptake of renewables. With renewable energy increasingly dominating power production, modernization of electricity transport and distribution, including options such as hydrogen and storage technologies, and electrification of energy end uses can become the drivers of decarbonization in the energy sector.

Technologies already exist for moving to decarbonized pathways. In 2016, nearly one fourth of electricity generation came from renewables, including solar PV and wind. However, progress has been hampered by slow progress in smart-grid management and long-term electricity storage. The amount of modern renewable energy in the total global energy supply increased by an average of 5.4 per cent annually over the past decade and for five years in a row (2014-2018), global investments in clean energy exceeded $300 billion annually. That was facilitated by the fact that, since 2009, the price of renewable electricity has dropped by 77 per cent for solar PV and by 38 per cent for onshore wind, while the cost of electricity from conventional sources has undergone only modest reductions.

Difficulties in adopting, at a sufficient scale, alternative energies to fossil fuels, including nuclear, hydro, bioenergy and other renewables, imperil substantial portions of the 2030 Agenda. Globally, direct and indirect subsidies to fossil fuels still far exceed subsidies to renewable energy, and such distortion of market prices is slowing the diffusion of renewable energy sources. Reliance on fossil fuels for transport remains massive. Shifts in consumer behaviour may reduce global oil use for cars, which is expected to reach its peak in the 2020s, but the demand for trucks, ships and aircraft continues to push overall oil demand for transport on a rapid upward trajectory. Global passenger demand (measured in passenger-kilometres) is expected to more than double between 2015 and 2050, with most of the growth occurring in developing economies. The positive benefits of electric vehicles for reducing greenhouse gas emissions and human exposure to pollutants may greatly vary depending on the type of electric vehicle, the source of energy generation, driving conditions, charging patterns and availability of charging infrastructure, government policies and the local climate in the region of use. Indeed, promotion of public transportation and slow mobility (e.g. walking and biking) remain key strategies for decarbonizing the

transport and energy sectors. With regard to biomass: it is a limited resource and should be prioritized for use in situations in which there is no obvious alternative, as its harvesting can lead to loss of biodiversity and trade-offs in terms of land rights, food security and access to water. Biomass burning is also a significant source of air pollution, therefore its use should be subject to strong regulations, and alternatives should be encouraged, particularly for cooking.

Between 1965 and 2015, world per capita energy consumption increased from 1.3 to 1.9 tons of oil equivalent but individual average consumption is three to four times higher in developed countries, where progress in energy efficiency has been able to limit only the rate of growth of demand. Because rising incomes and a growing population mostly added to urban areas in developing countries, at the world level, demand for energy is expected to increase by 25 per cent in 2040, and the increase could be twice as large were not for continued improvements in energy efficiency. According to the International Energy Agency, if annual investment in renewables does not at least double, and continues at the current pace, fossil fuels will retain a predominant role in supplying up to 78 per cent of total energy in 2030, and a similar share even in 2050. The direct consequence will be the persistence of the current negative trend of increasing greenhouse gas emissions, which will make it impossible to reach the Paris Agreement objective of holding the increase in the global average temperature to well below 2°C above pre-industrial levels.

In 2017, for the first time, the number of people without access to electricity dipped below 1 billion, but trends on energy access fell short of global goals. Nonetheless, with current trends, 650 million people, living predominantly in rural settlements in sub-Saharan Africa, are projected to remain without electricity in 2040.

The share of electricity in global final energy consumption is approaching 20 per cent and is set to rise further. A doubling of electricity demand in developing economies puts cleaner, universally available and affordable electricity at the centre of strategies for economic sustainable development and greenhouse gas emissions reduction. Electrification brings benefits – notably by reducing local pollution – and requires additional measures to decarbonize power supply if it is to unlock its full potential as a way to meet climate goals. The potential for progress is clear. The convergence of cheaper renewable energy technologies, digital applications and the rising role of electricity is a crucial vector for change. Solutions need to be context specific with energy mixes, including decentralized renewable energies, emerging from the disruptive changes in energy production and consumption, and presenting significant transition risks to long-term fossil fuel infrastructure investment.

Call to action

- All stakeholders must ensure universal access to affordable, reliable and modern energy services through the accelerated, cost-efficient provision of clean electricity coupled with making clean cooking solutions a top political priority and moving away from using traditional biomass for cooking. All stakeholders should promote clean, reliable and modern energy sources, including by harnessing the potential of decentralized renewable energy solutions.

- International and national entities and stakeholders must collaborate to reshape the global energy system so that it participates fully towards the implementation of Goal 7 by transitioning to net-zero CO_2 emissions by mid-century so as to meet the goals of the Paris Agreement including by introducing carbon pricing and phasing out fossil fuel subsidies.

E. Urban and peri-urban development

If current trends continue, cities will contain approximately 70 per cent of the world's population and produce 85 per cent of global economic output by 2050. The human and environmental impact of cities is staggeringly high, and imposes a high cost on surrounding rural areas. Ninety per cent of people living in cities breathe air that fails to meet WHO standards of air quality (10 micrograms per cubic metre (µg/m) of particulate matter); no metropolitan city in sub-Saharan Africa or Asia meets that standard. The water footprint of cities – their water source area – accounts for 41 per cent of the Earth's surface, while their physical footprint – their land area – covers only 2 per cent; the land occupied by cities in the developing world will triple by 2050. Cities are responsible for 70 per cent of the global greenhouse gas emissions from burning fossil fuels, and will need to become carbon neutral if the world is to achieve the targets contained in the Paris Agreement. If development continues in the business-as-usual model, the cities of the world will consume 90 billion tons per year of raw materials, such as sand, gravel, iron ore, coal and wood, by 2050, That will have irreversible consequences on the depletion of those finite resources, and will mean the destruction of natural habitats and green space, and resulting loss of biodiversity. In many cases, urbanization is proceeding organically, without planning, and since urban centres concentrate in coastal areas, urban residents live with a high risk of flooding, mudslides and other disasters.

In addition, cities give rise to the potential for severe income disparity and extreme inequality in health, food security, housing, education and access to meaningful social and cultural lives and fulfilling work. Globally, 35 per cent of urban populations have no access to municipal waste management. Persons with disabilities face several barriers to active life in many cities around the world when public transport, public buildings and commercial centres are not made accessible to them. In sub-Saharan Africa, more than half (56 per cent) of the urban population currently live in slums. In many North American and European cities, a wide income gulf separates the rich and poor, sometimes even within the radius of a few kilometres.

However, much urbanization takes place in areas where new infrastructure is being built, freeing cities from path dependencies and allowing for novel, sustainable solutions. Policy and investment decisions made today will have a deep and long-lasting impact based on that concentration of people and economic activities, but also because of the locked-in, long-term nature of urban systems – energy and water systems, transportation networks, buildings and other infrastructure. With key interventions, cities can become sustainable development leaders and laboratories for the world at large. A 2030 Agenda city will be compact and accessible to all, including women, youth, persons with disabilities and other vulnerable populations, with sufficient public transit and active mobility options, a flourishing economic base with decent jobs for all, accessible digital infrastructure and mixed land use, including residential, commercial, educational spaces and green public spaces.

Urban development should proceed in a well-planned, integrated and inclusive manner, with city governments working together with businesses, civil society organizations, individuals, national governments, the authorities in neighbouring peri-urban towns and rural areas, and peer cities around the world, leading to an active and dynamic movement. A new, robust science of cities can give urban policymakers around the world access to a body of knowledge and good practices.

Urban and peri-urban decision makers should take the central tenet of the 2030 Agenda to heart and ensure that no one is left behind in their cities and towns. That means prioritizing pro-poor development and access to decent jobs, effective public services, and safe and attractive public spaces for all, regardless of gender, age, ability and ethnicity. Bridging the last mile to those currently living without quality health care, education, safe drinking water and sanitation services, nutritious food and reliable transportation is critical, particularly because inequality is often extremely high in cities. Strengthening climate resilience and adaptation measures will be particularly important for vulnerable populations in coastal cities.

The reality of cities – people living in close proximity to one another – creates opportunities for fully decoupling economic growth from environmental degradation and advancing along sustainable pathways to development. Governments, businesses, civil society organizations and individuals can use a range of policy, economic and communications tools to promote sustainable consumption and production patterns through well-planned land use, effective urban public transport systems, including active mobility – walking and biking –, rapid scale-up of renewable energy and energy efficiency, and promotion of sustainable and technology-enabled businesses and jobs.

Innovative governments, a committed private sector and an active – and often, young and well-educated – citizenry can overcome inequalities and create liveable cities in both developing and developed countries. A liveable city will provide high-quality services and foster "naturbanity" – a close connection between people and nature to protect biodiversity, enhance human health and well-being, and strengthen climate resilience. Liveable cities can be smart cities that use technology to provide services in a more efficient and equitable manner. Liveable cities will also create more equitable and symbiotic relationships with the surrounding peri-urban and rural areas.

Call to action

- National governments should give cities the autonomy and resources to engage in effective, evidence-based and inclusive participatory policymaking with an engaged and informed citizenry.
- National governments and local city authorities, in close collaboration with the private sector, should promote people-centred and pro-poor policies and investments for a liveable city that provides decent, sustainable jobs, sustainable universal access to vital services such as water, transport, energy and sanitation, with effective management of all waste and pollutants. Individuals and communities should also scale up their engagement in advancing sustainable urban development.

F. Global environmental commons

The global environmental commons comprise the atmosphere, the hydrosphere, the global ocean, the cryosphere, polar regions, large-scale biomes and natural resources systems such as forests, land, water

and biodiversity, which make up the Earth's shared resources. The commons contribute to the functioning of the biosphere – the global ecological system – and are vital for human survival and well-being. Conditions on Earth are shaped by the interaction among all living organisms (biosphere) and the climate system. Consequently, changes in the biosphere's functioning caused by human activities are eventually reflected in the overall environmental conditions on Earth.

Ensuring the long-term health of the global environmental commons is therefore essential. Current human action is rapidly depleting and degrading the commons. There is an urgent need to manage how resources are extracted from the commons, how efficiently the resources are used, how they are distributed, and how waste is disposed of. Since the global environmental commons are intrinsically linked to one another, achieving sustainability of the Earth's systems requires anticipating feedback effects among the commons in order to maximize co-benefits and minimize trade-offs, both globally and locally.

Breaching the limits of those systems presents risks that incur severe social, economic and political consequences. In the Summary for policymakers of the global assessment report on biodiversity and ecosystem services (IPBES/7/10/Add.1, annex), the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) stated that "nature across most of the globe has been significantly altered by multiple human drivers, with the great majority of indicators of ecosystems and biodiversity showing rapid decline". Seventy-five percent of Earth's land surface has been significantly altered, 66 per cent of the ocean area is experiencing increasing cumulative impacts, and over 85 per cent of wetlands has been lost.

One immediate implication is that natural capital stocks that are necessary for most economic activities have been degraded and depleted. Much natural capital cannot be fully substituted by human-made infrastructure. For example, coastal flooding that often results from storm surges can be reduced by naturally occurring coastal mangroves or by human-made dikes and sea walls. However, built infrastructure is quite expensive, usually incurs high maintenance costs in the future and fails to provide additional benefits, such as nursery habitats for edible fish or recreational opportunities. Other ecological functions or ecosystem services are irreplaceable. Loss of biodiversity can permanently reduce future options – such as wild plants that might be domesticated as new crops or used for genetic improvement – and threatens resilience, as lost species may have been resistant to diseases, pests or climate change.

Biodiversity loss is particularly dire, with the global rate of species extinction already tens to hundreds of times higher than it has averaged over the past 10 million years, implying that nearly 1 million species already face extinction. Many pollinating species have declined in abundance and are threatened with further loss, putting the production of 75 per cent of food crops at risk. Local varieties and breeds of domesticated plants and animals are also disappearing. This unprecedented loss of biodiversity is driven by several interrelated negative externalities occasioned by human activity, including resource overexploitation, chemical pollution, fragmentation of land, introduction of invasive species, poaching, the disposal of plastics and, not least, climate change.

Other constituents of the global environmental commons are under threat: the atmospheric system is being degraded from greenhouse gas emissions, air pollution, stratospheric ozone depletion and persistent organic pollutants. Given the interconnections across the commons, those agents have severe deleterious effects on oceanic and terrestrial ecosystems. Climate change, for example, disrupts the supporting, regulating and provisioning services of ecosystems while increasing the intensity of hazards such as extreme heat, intense rainfall, floods, landslides, rise in sea level and drought. Air pollution presents one of the highest health risks globally, especially in fast-growing cities in developing countries, with 91 per cent of the world's population breathing air in which pollutants exceed the World Health Organization pollution guidelines. According to the World Health Organization, indoor and outdoor air pollution kills an estimated 8 million people per year.

The ocean provides critical regulating and provisioning services that synergistically support most of the Sustainable Development Goals. Securing the ocean can feed and provide livelihoods for people and, at the same time, maintain habitats, protect biodiversity and coastal areas, and regulate climate change through its role as a carbon sink. Projected changes in the ocean are expected to create feedback that will lead to greater global warming. Warming itself, coupled with ocean acidification – which is caused by carbon uptake – attacks coral reefs and impacts biodiversity, local livelihoods and coastal protection. The ocean supports the livelihoods of 40 million fishers; however, overfishing and ocean acidification threaten those livelihoods. The ocean also receives a growing amount of garbage, sewage, plastic debris, anthropogenic nanoparticles, fertilizers, hazardous chemicals and oil, all of which endanger marine species and biodiversity, contaminate human food chains, pose risks to the human immune system, reduce fertility and increase the risks of cancer.

A similar picture emerges with regard to land systems. Despite international and national efforts to limit deforestation, forests worldwide have been disappearing at an alarming rate. No less than 1.3 million square kilometres of forests have been lost since 1990, mostly in tropical regions (South and Central America, sub-Saharan Africa and South-East Asia), covering an area equivalent to the size of South Africa. Those forests were cleared for agriculture, access to extractive resources, urbanization and other reasons. In particular, Earth's two largest rainforest areas, the Amazon rainforest in South America and the Congo rainforest in Central Africa are key to global environmental health. They influence climate change, through their crucial role in carbon capture and storage, affect weather patterns across the two continents, and safeguard unique species and biodiverse communities. Capturing carbon by avoiding deforestation is more efficient than afforestation because old-growth forests capture more carbon than recently planted trees. Protecting existing old-growth forests creates simultaneous benefits for biodiversity, cultural and ecosystem services, climate change mitigation and adaption for people.

Achieving land degradation neutrality can contribute to accelerating the achievement of the Sustainable Development Goals. Restoring the soils of degraded ecosystems has the estimated potential to store up to 3 billion tons of carbon annually. Climate-smart land management practices, including low-emissions agriculture, agroforestry and restoration of high-carbon-value ecosystems, such as forests and peatlands, nearly always come with adaptation co-benefits.

The effects of depletion can also be clearly observed in the case of freshwater availability. It is expected that by 2025, 1.8 billion people will experience absolute water scarcity, and two thirds of the world's population will be living in water-stressed conditions. Drought and water scarcity are considered to be the most far-reaching of all natural hazards, causing short- and long-term economic, health and ecological losses. Land restoration raises groundwater levels, increases crop yields and induces positive changes in the fauna of the region concerned, as exemplified by recent evidence from Ethiopia and Niger.

At all levels, it is essential to reverse the trend of overexploitation of the global environmental commons. Exploitation must be managed within boundaries that maintain the resilience and stability of natural ecosystems, and allow for the natural renewal of resources.

Multilateral agreements, such as the United Nations Framework Convention on Climate Change, the Convention on Biological Diversity and the United Nations Convention to Combat Desertification, are mechanisms to protect the global environmental commons and guarantee their global sustainable management. Importantly, each agreement is supported by a formal scientific advisory body: the Intergovernmental Panel on Climate Change, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, and the Committee on Science and Technology, respectively. That suggests that science diplomacy can improve the management of the global environmental commons and support partnerships to effectively manage the commons in conflicting contexts.

However, ensuring the sustainability of the global commons is not just a matter of global governance; a plethora of actions at all levels – from global to local – and involvement of the most directly affected communities is equally important. Indeed, policies must address hard-to-change behaviours that are damaging to the environment, including economic incentives such as removing harmful subsidies, introducing appropriate taxation, and regulation such as progressive carbon taxation mechanisms. Empowering people to make positive change through education, awareness raising and social movements is critical. Social acceptability of those much-needed changes will be facilitated if management of the global commons explicitly addresses human well-being and environmental injustice. Such management should avoid maldistribution and seek to repair the damage already caused by poor technical, financial and political interventions. especially where indigenous communities and other vulnerable groups are concerned, with concerted efforts to leave no one behind.

Call to action

- Governments, local communities, the private sector and international actors must urgently achieve the necessary transformations for conserving, restoring and sustainably using natural resources, while simultaneously achieving the Sustainable Development Goals.
- Governments must accurately assess environmental externalities – in particular those that affect the global environmental commons – and change patterns of use through pricing, transfers, regulation and other mechanisms.

G. Science for sustainable development

For better or for worse, science and technology are powerful agents of change, depending on how they are steered. Guided by the 2030 Agenda, increased

science-policy- society cooperation can harness breakthroughs in our understanding of coupled human-environment systems and the shaping of innovative pathways towards achieving the Sustainable Development Goals. The fact that a large number of countries are now incorporating science, technology and innovation in their national development agenda is a promising sign.

Despite the economic and financial crisis of 2008–2009, expenditure on research and development increased worldwide by 30.5 per cent between 2007 and 2013 – more than global GDP (up 20 per cent). The number of researchers worldwide expanded by 21 per cent and the number of scientific publications grew by 23 per cent. Moreover, there is a growing tendency for governments and companies to invest in sustainable technologies. Recent reports show that, over the past 10 years, at least 101 economies across the developed and developing world (accounting for more than 90 per cent of global GDP) adopted formal industrial development strategies, which increased opportunities for formulating new ways to promote innovations toward sustainable development. However, developing technology alone is not enough: technology must be made available, accessible and sufficiently attractive to encourage widespread adoption. Hence, in addition to research and development, the scaling up and the adoption of sustainable technologies are critically needed.

Rapid technological advances in computer sciences, artificial intelligence and biotechnologies hold the promise of providing solutions to many of the challenges facing the Sustainable Development Goals, including those that involve difficult trade-offs. For example, technology can facilitate accessibility to built environments, transport and information and communication services, promote inclusion and help realize the full and equal participation in society of the 1 billion persons with disabilities worldwide.

At the same time, technological innovations risk further entrenching existing inequalities, introducing new ones and, through unintended consequences, setting back progress towards the 2030 Agenda. For example, without access to digital infrastructure and accessible information and communication technology, persons with disabilities are at increased risk of being excluded from statistics and surveys used to develop future programmes and policies.

The Multi-stakeholder Forum on Science Technology and Innovation for the Sustainable Development Goals, part of the Technology Facilitation Mechanism mandated by the 2030 Agenda and the Addis Ababa Action Agenda, has already met four times in New York. The Forum is intended to provide a venue for facilitating interaction between relevant stakeholders in order to identify and examine needs and gaps with regard to science and technology, innovation and capacity-building, and to help facilitate development, transfer and dissemination of relevant technologies for the sustainable development goals.

Furthermore, international scientific assessments that have already contributed to tracking progress and identifying barriers towards sustainable development can synthesize existing knowledge and build consensus on key insights. They also provide crucial advice for policymaking. Going forward, more effort is needed to integrate regional perspectives and maximize synergies between different assessments.

Despite those advances, significant gaps remain for bridging the scientific and technological divide between developed and developing countries. The highly uneven global distribution of scientific capacity and access to knowledge threatens to derail the 2030 Agenda. Over 60 per cent of total scientific literature and most research and development are carried out in high-income countries. Facilitating multidirectional science and technology transfers from North to South and from South to North and through South-South collaborations will contribute to better aligning progress and innovation trajectories to meet the needs of the 2030 Agenda. Ultimately, the universality of the Agenda requires that every country have at its disposal the necessary science and technology to devise the transformative pathways to respond to its specific characteristics, needs and priorities.

On the gender equality front, although the number of women in science and engineering is growing at the global level, men still outnumber women, especially at the upper levels of those professions. Even in countries where girls and boys take math and science courses in roughly equal numbers, and about as many girls as boys leave secondary school prepared to pursue careers in science and engineering, fewer women than men actually do so. Actively promoting gender equality in the sciences has the potential to lead to substantial knowledge, social and economic gains.

States are currently spending relatively little on research and development to implement the 2030 Agenda. During the post-war golden era of economic growth, basic research, as well as radical invention risk-taking and technological innovation, were financed largely by the public sector. Nowadays, most research is driven by commercial interests or funded by private funds and philanthropic organizations – and is concentrated in certain countries. That phenomenon is worrying because meeting today's

challenges and circumventing vested interests requires rapid, unprecedented funding, with an appropriate balance between public and private investments, and a significant increase of research capacities in all developing countries. Very little of the current research investment is focused on elucidating the interactions between levers and actions that are so critical for achieving the Sustainable Development Goals.

The urgent need for sustainable transformations requires strengthening the directionality of science on behalf of a mutually beneficial "moon landing" for humanity and the Earth. Researchers, science policymakers and funding agencies can use the 2030 Agenda as a shared compass to increase the relevance and benefits of science and technology for the global community.

In recent decades, scientists have begun to address the web of challenges facing humanity, with interdisciplinary research focused on coupled human-environment systems or socio-ecological systems. That has given birth to a new, more engaged academic discipline – sustainability science – that draws on all scientific disciplines, including social sciences and humanities in a problem-solving approach, and seeks to shed light on complex, often contentious and value-laden nature-society interactions, while generating usable scientific knowledge for sustainable development. Sustainability science can help tackle the trade-offs and contested issues involved in implementing the 2030 Agenda, such as dealing with risks, uncertainty, ethical dimensions and the appropriate use of the precautionary principle. It involves working with affected groups and communities to recognize problems and goals, and identify key trade-offs. Sustainability science has attracted tens of thousands of researchers, practitioners, knowledge users, teachers and students from diverse institutions and disciplines across the world. However, massive investment from the scientific and engineering communities, as well as funding bodies, is still needed.

Call to action

- Stakeholders must work with the academic community in all disciplines to mobilize, harness and disseminate existing knowledge to accelerate the implementation of the Sustainable Development Goals.
- Governments, research consortiums, universities, libraries and other stakeholders must work to enhance the current levels of access to knowledge and disaggregated data, and scientific capacity and good-quality higher education, in low- and middle-income countries and countries in special situations. They must also actively promote gender equality in science and engineering.
- Universities, policymakers and research funders must scale up support to mission-oriented research, guided by the 2030 Agenda, in sustainability science and other disciplines, with simultaneous strengthening of the science-policy-society interface.
- All stakeholders should make deliberate efforts to facilitate multidirectional (North-South, South-North and South-South) transfers of technologies for achieving the Sustainable Development Goals.

H. Not incremental change but transformation

The 2030 Agenda is more than the sum of measurable Goals, targets, and indicators. It is both a normative orientation and a guide for action for identifying and pursuing sustainable development priorities and creating coherence between policies and sectors, in all contexts – local, regional, national, transnational and global. While the six entry points and four levers proposed in the Global Sustainable Development Report indicate a general plan of action, they do not provide an exhaustive coverage of the challenges to achieving the 2030 Agenda. The entry points and levers should rather be used as references to guide countries and all actors in their own context-specific implementation strategies for achieving the Sustainable Development Goals and in their assessment of the Goals-related trade-offs that are underlined in the Report.

To conclude, the first quadrennial edition of the Global Sustainable Development Report proposes three final global calls to action that would be especially helpful for the implementation of the other 17 calls for action issued therein, in a way that would appropriately take into account the interlinkages across all Goals and the holistic character of the 2030 Agenda.

Call to action

- Multilateral organizations, governments and public authorities should explicitly adopt the Sustainable Development Goals as a guiding framework for their programming, planning and budgetary procedures. To accelerate the implementation of the 2030 Agenda, they should devote special attention to directing resources – including finances, official development assistance at levels that meet international commitments, and technologies – to the six entry points, applying knowledge of the interlinkages across Goals and targets, contributing to the realization of co-benefits and resolving trade-offs. The United Nations and other international and regional organizations

should facilitate exchange of information and dissemination of lessons learned on the use of the Sustainable Development Goals framework among countries.

- The four levers of change – governance, economy and finance, individual and collective action, and science and technology – should be coherently deployed and combined to bring about transformational change. All actors should strive for coordinated efforts and prioritize policy coherence and consistency across sectors.

- Every country and region should design and rapidly implement integrated pathways to sustainable development that correspond to their specific needs and priorities, and contribute also to the necessary global transformation.

Chapter I

Chapter I

The transformative power of sustainable development

Science now recognizes the Earth as a closely linked human-environment system, and provides a better understanding of the extent to which our shared progress as human beings is undermined by the ways in which we have gone about achieving it. Governments can lead the transformation of the world's social, economic and environmental status towards universally beneficial outcomes when guided by the Sustainable Development Goals. But they must recognize that such transformation will involve tough choices and trade-offs.

In September 2015, United Nations' Member States decided jointly on a global project to shape our common future in a new, better and more intentional way. Building upon wide consultations with civil society representatives, business people, scientists and others, they established the 2030 Agenda for Sustainable Development. Entitled *Transforming Our World,* this project reflects the global community's high expectations of finally reversing the destruction of our natural and social habitats, and achieving a more balanced and equitable pathway towards the well-being of all.

In many ways, this project can be seen as the latest stage of a long process of change that started in 1972 with the United Nations Conference on the Human Environment, in Stockholm, and included the United Nations Conference on Environment and Development – the Earth Summit – held in Rio de Janeiro in 1992, the Millennium Declaration adopted by the General Assembly in 2000, and the United Nations Conference on Sustainable Development (Rio+20 Conference) in 2012. But the 2030 Agenda, with its focus on transformation, also represents a change of gear. *Transformation* differs from evolutionary or chaotic change, in that it is intentional change based on societal agreement and factual understanding, and achieves outcomes at scale.[1, 2, 3]

Indeed, many of the Sustainable Development Goals carry forward the unfinished business of the Millennium Development Goals, while several others can be traced back to objectives already agreed to in different United Nations forums. What is unique about the Sustainable Development Goals is that they have been brought together within one framework as an *indivisible* and *universal* whole. Therefore, not only the Goals and targets, but also the *interactions* among them, are brought into focus in the 2030 Agenda. The emphasis on interactions was likely influenced by the growing scientific understanding of the Earth as a closely linked human-environment system.[4, 5, 6] Past and current gains in human well-being have come almost always at the expense of the Earth's resources. Such costs emerge from both the direct removal and use of living organisms and non-living resources from the Earth's surface, and through the release of waste into the air, land and water.

There is no question that, on average, human well-being has been continually improving over recent times. Today, although serious deprivations persist, the people across the world live, on the whole in unprecedented prosperity.[7] However, the environmental and

social costs of achieving that level of well-being for the growing world population are now obvious at the planetary level.

Since the middle of the twentieth century, human-caused global change has accelerated sharply,[8,9] creating multiple ecological pressures on the Earth. Those pressures are already too great to guarantee a safe habitat for future generations.[10]

Changes in global conditions may appear slow and of little concern at present; however, scientific understanding of how conditions on Earth have changed in the past indicates that what, at first glance, may look like a small and unimportant change can trigger sudden, dramatic and irreversible changes in the Earth's conditions. The Earth system is extremely complex and once beyond certain thresholds, even minor changes can lead to major events with drastic and irrevocable consequences. As a result, the Earth can reach tipping points. In the climate system, for example, tipping points are found where increasing global warming can lead to rapid changes, such as the melting of the Arctic summer sea ice, or the permafrost, that further accelerate global warming in a vicious circle leading to an irrevocable change.[11, 12] Thus, the accumulated impacts of human activities on the planet now present a considerable risk of the Earth system itself being changed beyond recognition, with grave consequences for humanity and all life on the planet.

However, not all humans are equally responsible for the impact that humanity is having on our planetary home: neither do all humans benefit equally from the activities that produce that impact. There is a very clear and well-recognized detrimental relationship between the standard of living and the ecological footprint (elaborated subsequently). A large part of the world's population is still experiencing critical human deprivations and lacks dignified living conditions, even as many others experience high standards of living, but at an aggregate environmental cost that is borne by all.[13, 14]

In view of that alarming level of inequality, the challenge of achieving sustainable development is to secure human well-being in ways that are not only *safe*, in terms of not threatening the Earth system with irreversible change, but also *just*. Ultimately then, sustainable development should be pursued in the spirit of finding pathways that enable a good life for all, leaving no one behind, while safeguarding the environment for future generations and ensuring planetary justice.

Since humankind is shaping both the Earth system and societies, humans must also assume responsibility for their health.[15, 16] We need to solve the problems relating to poverty, inequality and the rapidly deteriorating environment, and urgently. Indeed, the primary window of opportunity for change could be within the coming decade.[17, 18]

The 2030 Agenda is a globally agreed mandate for transformation. Nevertheless, it must compete with powerful oppositional interests that benefit from the status quo or even intensify socially and environmentally damaging activities. The status quo may seem attractive in the short term, but it is clearly unsustainable and with negative longer-term consequences that will ultimately lead to chaotic and destructive outcomes.

The present Report presents a scientific take on integrated ways to accomplish the transformation of our world, in response to the request made of the scientific community at the high-level political forum on sustainable development in 2016 (see box 1-1). Scientific knowledge has long informed policymaking – helping to ground actions in evidence –, and a rational understanding of how the world works. The Global Sustainable Development Report continues the practice of speaking to policymakers, but also seeks to inform the decisions of a broader range of stakeholders whose actions will ultimately determine how the 2030 Agenda is achieved.

The present Report identifies six essential entry points, where the interconnections across the Sustainable Development Goals and targets are particularly suitable for accelerating the necessary transformation. Those entry points are:

- Human well-being and capabilities
- Sustainable and just economies
- Food systems and nutrition patterns
- Energy decarbonization and universal access
- Urban and peri-urban development
- Global environmental commons.

The Report also identifies four levers that can be applied to those critical entry points in order to right the balance between achieving human well-being and its social and environmental costs. The levers are:

- Governance
- Economy and finance
- Individual and collective action
- Science and technology.

The present Report considers how science can best accelerate the achievement of the Sustainable Development Goals.

It argues in favour of a *sustainability science* as a new way for science to contribute directly to sustainable development.

Box 1-1
The Global Sustainable Development Report

The high-level political forum on sustainable development is the United Nations central platform for the follow-up and review of the 2030 Agenda for Sustainable Development that was adopted by the General Assembly in September 2015. At the first forum, held in 2016, Ministers and high representatives adopted a declaration in which they decided on the ways in which the forum would go about its task and agreed on the importance of science to inform their deliberations. It was decided that the high-level political forum would be informed by an annual progress report on the Sustainable Development Goals to be prepared by the Secretary-General and based on the global indicator framework and data from national systems; and a quadrennial Global Sustainable Development Report, which would provide deeper analysis, drawing upon a wide range of scientific inputs and assessments, and strengthen the science-policy interface. That strengthened and clarified the mandate of this report, made at the Rio+20 conference, and previously met through annual versions in 2014, 2015 and 2016.

The present Global Sustainable Development Report is the first report in the quadrennial cycle. It was prepared by an independent group of scientists appointed by the Secretary-General. The Group has addressed sustainable development as both a scientific and a normative concept, using it as a guide to analyse the problem, weigh the evidence and, where needed, recommend policy-relevant solutions for sustainable development. For that purpose, the 2019 Report follows not just the letter but also the spirit of the 2030 Agenda, with the overarching goal of advancing human well-being in an equitable and just fashion, and ensuring that no one is left behind even as the natural systems that sustain us are safeguarded.

In addition to reviewing the state of global sustainable development, the Group was tasked with incorporating in an interdisciplinary manner the latest evidence from the natural and social sciences to support the implementation of the 2030 Agenda in promoting poverty eradication and sustainable development, while strengthening the science-policy interface. The Report also considers regional dimensions and diversity, as well as countries in special situations.

In keeping with its mandate, the Group did not seek to produce new evidence. Rather, the Report capitalizes on existing knowledge across various disciplines, through an assessment of assessments. It seeks to highlight state-of-the-art knowledge for transformations for sustainable development and identifies concrete areas where rapid, transformational change is possible. The Report is not only a product but also a process for advancing collaboration across the science-policy-society interface across the world in order to identify and realize concrete pathways for transformation. Although it is a report on global sustainable development, the Group advocates that it be used to initiate science-policy-society collaboration and learning at the national and regional levels with a view to co-designing context-specific pathways for sustainable development.

1.1. Understanding sustainable development in the 2030 Agenda

Commencing in 2000, the Millennium Declaration and its associated Millennium Development Goals guided development efforts through the first 15 years of the new century. That experience showed that goal setting and periodic assessments based on measurable indicators could and did spur progress and coordinated action.[19, 20] In the pursuit of the Millennium Development Goals, the global community achieved many successes, but also fell short in several ways as it learned important lessons about the opportunity of co-benefits, and the inevitability of trade-offs and tough choices.

Co-benefits, trade-offs and tough choices are at the heart of sustainable development but have not always been appreciated as such. Initial interpretations that emphasized three distinct dimensions of sustainability – economic, environmental and social – tended to reinforce decision-making in thematic silos. The result, typically, was to prioritize immediate economic benefits over social and environmental costs that would materialize over the longer term. However, such an approach also continually deferred consideration of the difficult choices that needed to be made – indeed, the very usefulness of the concept of sustainable development came under question.[21]

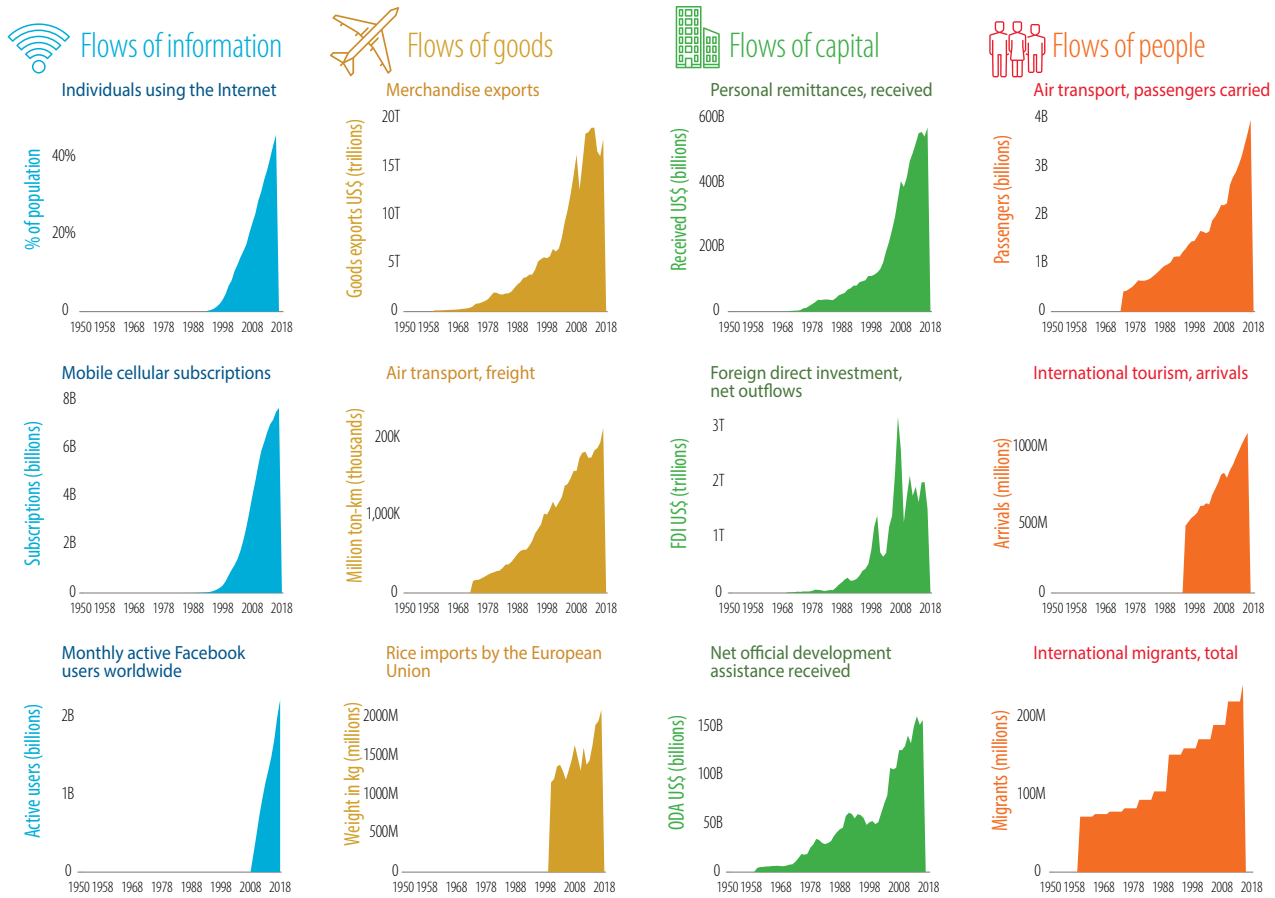
The present Report strives to address this head-on by adopting a systemic approach to the Sustainable Development Goals, informed by the knowledge of

the interactions among them. In this way, it identifies the biggest transformative potentials of the 2030 Agenda, not through the pursuit of individual Goals and targets but rather by explicitly considering their interlinkages and resultant co-benefits and trade-offs. In an increasingly globalized and hyper-connected world, any intervention on behalf of just one Goal can lead to unintended consequences for the achievement of other Goals nearby or faraway, today or tomorrow. Conversely, the chances of progress on one Goal in a specific part of the world will depend on interventions made in other sectors, in sometimes distant places. Those interactions often imply trade-offs, but also give rise to co-benefits and the significant potential for transformations towards sustainable development.

The key to the implementation of the 2030 Agenda thus lies in leveraging interactions among the Sustainable Development Goals away from trade-offs and towards co-benefits, from vicious to virtuous circles. Based on existing assessments and evidence, the Report begins by considering where we are today in the pursuit of sustainable development. It then identifies systemic entry points for transformation that could accelerate the implementation of the 2030 Agenda across multiple Goals and targets. These entry points are the means to harness important synergies, multiplier effects and trade-offs across several Goals so as to accelerate progress. They help to identify the levers and actors that can make it happen. At the country level, the entry points could serve to introduce a more integrated approach towards implementation and assessment underlined in the Report. Countries and subnational entities could then develop acceleration roadmaps based on the scientific evidence most relevant to their circumstances and context.

Figure 1-1
Cross-national flows of information, goods, capital and people

Cross-national flows of information, goods, capital and people increased dramatically in the last decades, underpinning a world that is more interconnected than ever.[22]



1.1.1. An increasingly interconnected world

The world is now closely interconnected by flows of goods, capital, people and information. Those flows overlap and interconnect and link the development of nations and regions across North and South, global and local, today and tomorrow (see figure 1-1). The flows produce many benefits: for example, through remittances, finances are transferred from richer parts of the world to poorer ones and using the Internet can give small entrepreneurs and artisans access to the global marketplace.

On the other hand, the flows can also result in or propagate negative impacts, such as deepening inequalities, unfair competition, resource depletion and environmental pollution and destruction. In many cases, such as with unsustainable resource use or environmental degradation, those impacts can be seen as a transfer of the problem beyond national jurisdictions, and present challenges for countries that may be ill-equipped to deal with them.

The flows interact with the natural interconnections across the Goals, so that decisions and actions in one country or region can affect outcomes in another one, and even leave footprints all over the world. Conversely, the most effective solutions to critical sustainability problems in one country may be found through action in others, facilitated by international collaboration. As a result, States may sometimes feel they have less autonomy to shape their own development. While this can lead to States and communities feeling disempowered, it is also an opportunity for them to work collectively towards a shared future based on sustainable development.

The world in the twenty-first century is therefore marked by close systemic interlinkages with positive synergies, but also negative interactions and externalities that imply difficult trade-offs between various dimensions – sectoral, local, regional, global and temporal. Advancing the 2030 Agenda must involve an urgent and intentional transformation of socio-environmental-economic systems, differentiated across countries, but also aggregating up to provide the desired regional and global outcomes, so as to ensure human well-being, social justice and limited environmental impact.

1.1.2. A vision for 2030 and beyond

The 2030 Agenda calls for eradicating poverty and other deprivations, enhancing human capabilities, reducing inequalities, fostering peace, reversing the degradation of the planet, and strengthening the Global Partnership for Sustainable Development. For that purpose, the Agenda provides a detailed roadmap in the form of carefully elaborated Goals, targets and indicators. But the Agenda is more than a long wish list, it is also an integrated vision of how to achieve the Sustainable Development Goals, while jointly advancing the well-being of humanity and the planet, ensuring that natural resources can be shared and conserved for the well-being of the world's people in 2030 and beyond.[23] Connections across Goals and targets also imply the need to make difficult choices, with the potential of producing winners and losers. Sustainable development, while identifying a bridge to the future, is inevitably dependent on the making of choices through the political process.

Achieving transformation – a profound and intentional departure from business as usual – will mean carefully taking into account the interactions between the Goals and the targets. Policymakers will find both areas of support and contradictions among them, as well as systemic interactions and cascade effects as action towards one Goal can alter the possibilities for achieving others.[24] Much is known about those important interactions, even as they remain to be fully explored, with considerable research underway.

1.1.3. Understanding the importance of interactions

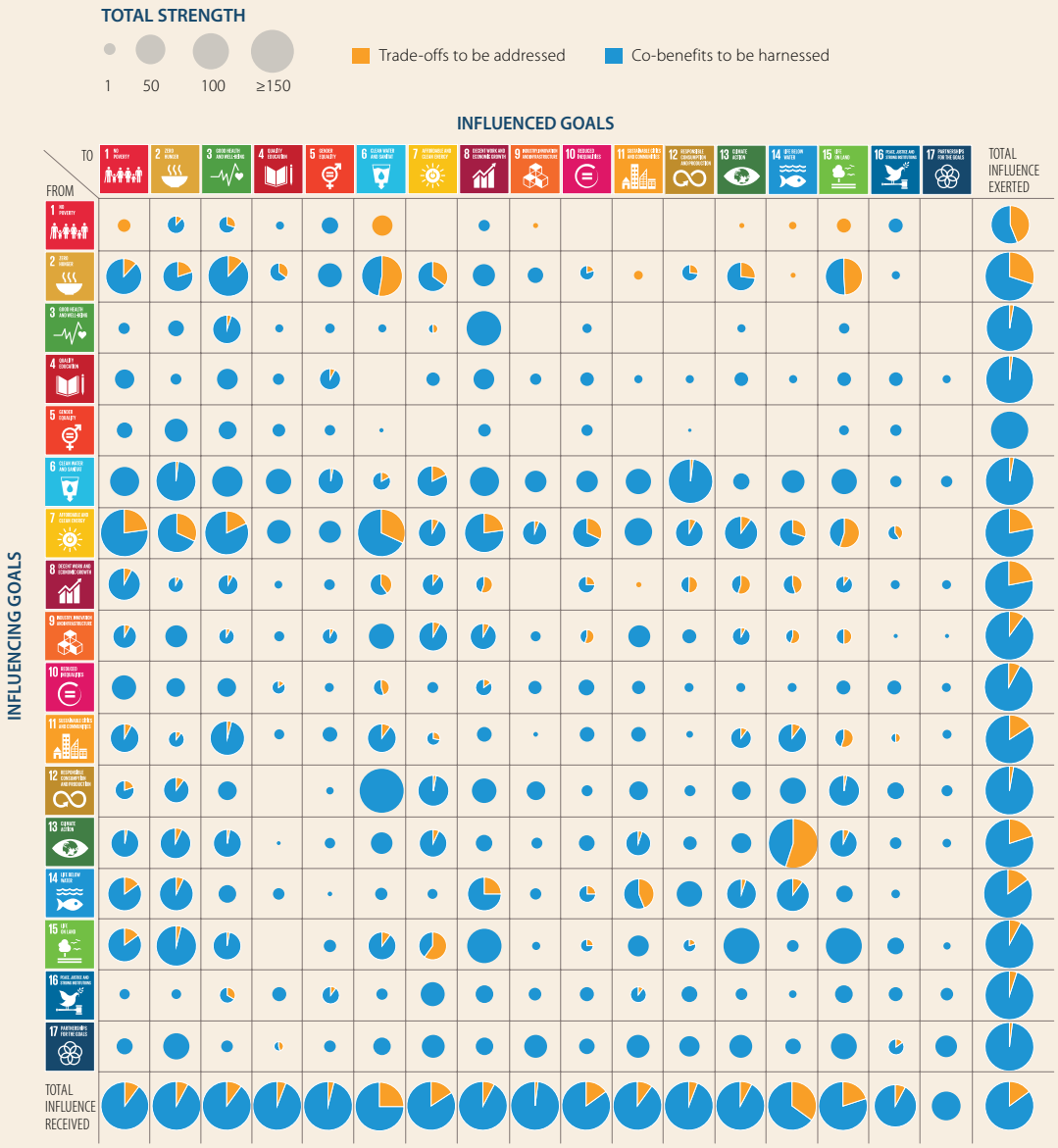
An assessment of current knowledge about the interactions between the targets demonstrates both gaps and progress (see box 1-2) Based on 112 scientific articles with explicit reference to the Sustainable Development Goals, as well as 65 global assessments, it shows that only about 10 per cent of the potential target-level interactions are covered at least once, and significant blind spots remain, clearly underscoring the need for further research on those interactions.

Dealing with such complex synergies and trade-offs poses a challenge for planners and decision-makers.[25] But these systemic interactions offer already identified and sometimes unexpected solutions for seemingly insurmountable problems. For example, governments can replace the frequently rigid and sequential development paths that place economic growth ahead of social equity and environmental protection. Instead, policymakers can adopt systemic approaches, following different pathways to sustainable development that offer multiple solutions and drivers, across different sectors and jurisdictions. Effective action in different systems will require that the links among them be acknowledged and addressed – the connection between climate change and human health, for instance, or between climate change and inequalities.

1.1.4. Engaging diverse actors

Those activities can be undertaken by a diverse group of stakeholders and organizations, other than governments of United Nations Member States alone. At the local, national and international levels, new key development actors are emerging and gaining greater power and influence. Innovative and powerful partnerships can result from collaborations between traditional stakeholders and emerging actors. The success of the 2030 Agenda depends on the cooperation of governments, institutions, agencies, the private sector and civil society across different sectors, locations, borders and levels.

Box 1-2
Interactions among Sustainable Development Goals



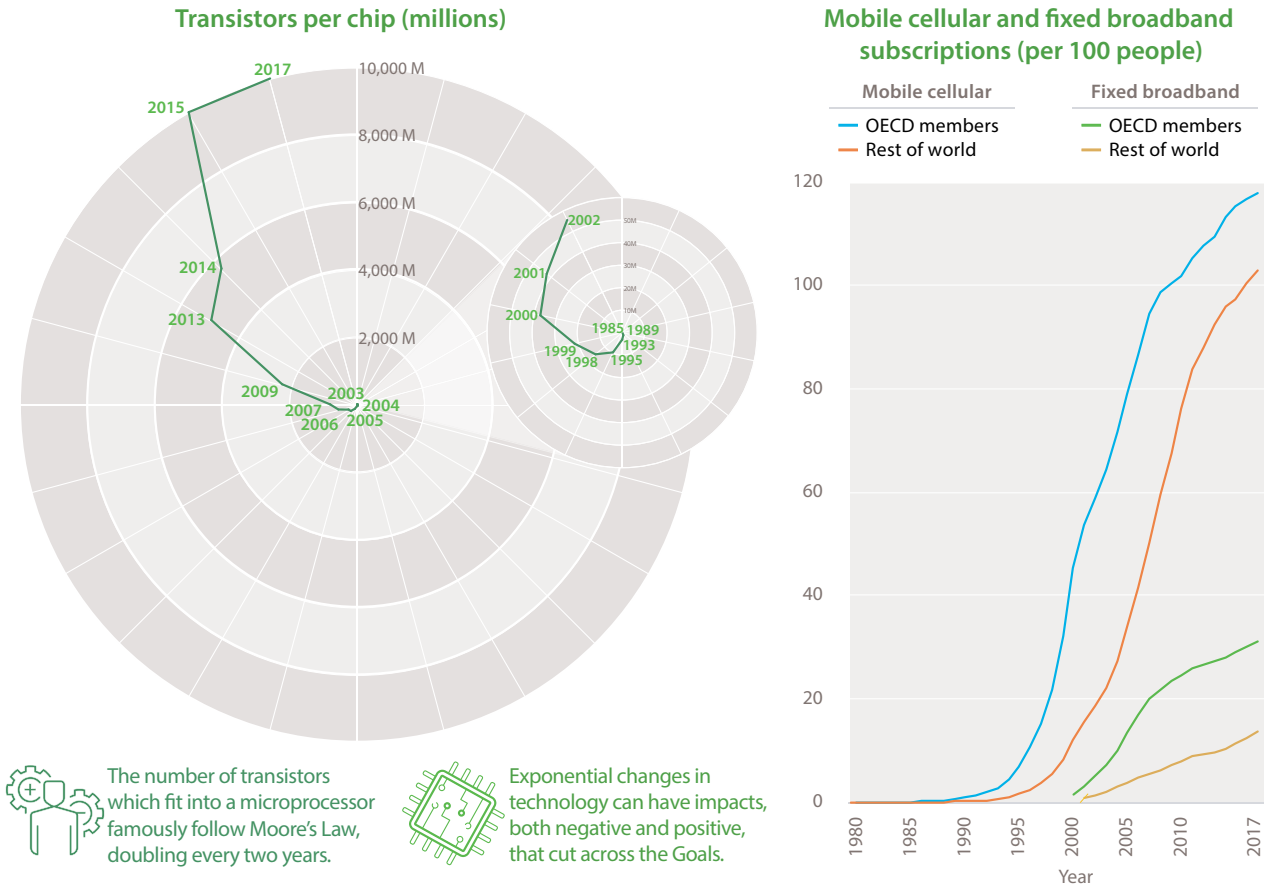
The figure above shows the result of a systematic compilation of knowledge about causal interactions among the Sustainable Development Goals, extracted primarily at the target level and using the 7-point scale developed by the International Council for Science (ICSU)[26] in terms of co-benefits

and trade-offs. The compilation is based on a total of 65 global assessments comprising United Nations flagship reports and international scientific assessments, as well as 112 scientific articles published since 2015 with explicit reference to the Sustainable Development Goals. Mapping the summed scores of influencing (horizontal) and influenced (vertical) interactions among the Goals, this assessment of assessments reveals the relative importance of the potential trade-offs, but the dominance of positive (blue) over negative (red) interactions in the current body of knowledge suggests that recent research has brought to the fore extensive co-benefits as well. The figure also shows important blind spots or gaps in knowledge where certain cells in the matrix are left blank. Of all possible target-level interactions, only about 10 per cent were covered at least once. Aggregated to the Goals level, however, the matrix reveals that 92 per cent of Goal-level interactions were assessed. In systemic terms, the figure suggests that change towards achieving the Sustainable Development Goals offers many opportunities for reinforcing rather than inhibiting itself.

1.1.5. Taking advantage of technology

The success of the 2030 Agenda will also require deliberate engagement with other trends that are already playing out across the world. One of the most immediate trends is the rapid advance of technology (see figure 1-2). Indeed, technology can generate solutions to many of the challenges relating to the Sustainable Development Goals, including some that currently involve difficult trade-offs. At the same time, technology risks further entrenching existing inequalities, introducing new ones and, through unintended consequences, setting back the vision of the 2030 Agenda.[27] Those issues are explored in chapter 3.

Figure 1-2
Technology: exponential increases in power and rapid adoption, but inequalities in access remain



1.1.6. Adapting to demographic change

The world population is still growing, but growth rates vary considerably across regions. The largest growth rate is in sub-Saharan Africa, where the population is projected to double by 2050.[28] In Europe and Northern America, as well as Eastern and South-Eastern Asia,[29] on the other hand, birth rates are low. Together with increasing life expectancy, this results in growing proportions of older persons in the populations of these regions.

Meeting basic needs, providing opportunities and enhancing the well-being of a larger and aging world population may strain social, economic and environmental resources. At the same time, improving human capital through access to high-quality education and health increases the capacity for global resilience. In most countries, the younger cohorts of the population are better educated than the older ones, which implies future progress in human capital.[30]

Historically, fertility and mortality rates have fallen with higher levels of education and economic opportunity for women and girls. It is thus expected that current advances in human capital will impact the future size and age composition of the global population.

1.2. Progress to date

The 2030 Agenda is both a normative orientation and a guide for action. It identifies and pursues development priorities while requiring coherence among all policy areas and sectors, at the local, regional, national and transnational levels.

Since the adoption of the Sustainable Development Goals, there have been many positive initiatives. Countries have started to incorporate the Goals into national plans and strategies, and many have set up coordinating structures for coherent implementation.[31] Of the 110 voluntary national reviews submitted during the 2016, 2017 and 2018 sessions of the high-level political forum, 35 mentioned explicit measures to link the Goals to their national budgets or were considering such action.[32] That is an important step as incorporating the Sustainable Development Goals into national budgets can improve programming. A number of countries have set up coordination structures to ensure the coherent implementation of the Goals across sectors. There have also been initiatives directed towards nature, notably regarding climate change, land use or the oceans. Furthermore, important parts of the private sector have begun to move away from business-as-usual models, for example, by adopting and reporting on sustainability standards.[33] Meanwhile, the mobilization of civil society and non-governmental organizations in favour of sustainable development is rising.

Over time, sustaining such efforts can significantly advance the achievement of the Sustainable Development Goals. However, the initial efforts have not yet reversed several negative trends that stall progress towards sustainable development. The limited success in implementing the 2030 Agenda should raise strong concerns, and even sound the alarm for the international community. Much more needs to be done and quickly to bring about the transformative changes that are required: impeding policies should urgently be reversed or modified, and recent advances that holistically promote the Sustainable Development Goals should be scaled up in an accelerated fashion.

1.2.1. Where we are and what we can expect

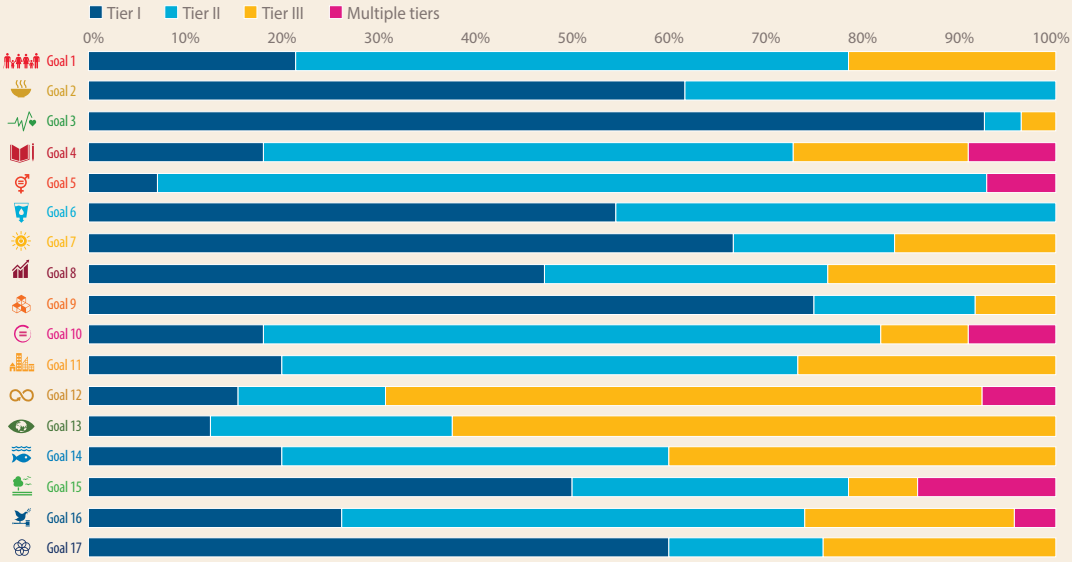
The scale and scope of what is needed can be seen by examining the rates at which progress is being made towards the numerical targets (see box 1-3) associated with the Sustainable Development Goals.[34] The rate of progress towards each target – assuming they continue unchanged - can be used to estimate whether that target will be achieved or, if not, how closely it will be approached by 2030. Table 1-1 shows the current state of play at the global level for some selected indicators for which adequate data are currently available. It draws primarily upon the database used for preparing the Secretary-General's annual progress reports on the Sustainable Development Goals.

Box 1-3
The Global Monitoring Framework

The 2030 Agenda defined 17 Sustainable Development Goals and 169 targets. Tracking progress towards these targets at the global level is made possible by indicators that are consistently defined and measured across countries. The Inter-Agency and Expert Group on Sustainable Development Goal Indicators has developed a global indicator framework that was agreed by the United Nations Statistical Commission at its forty-eighth session in March 2017, and adopted by the General Assembly in July 2017.

There are currently 232 indicators in the global framework, classified into three tiers depending on their level of methodological development and the availability of data. Tier I indicators are well defined, with sufficient data regularly collected at the country level for reliable and timely global reporting; Tier II indicators are well defined, but data are not regularly collected at country level; Tier III indicators are those for which definitions, methodologies or standards are under development.

More indicators have been moving into Tier I over time, and progress is being made in strengthening the conceptual and methodological foundations of the remaining Tier III indicators. As of May 2019, out of the 232 indicators, 104 were Tier I, 88 were Tier II, 34 are Tier III and 6 are categorized under multiple tiers (different components of the indicator are classified into different tiers).[35] The share of indicators within each tier varies across goals (see below):



The process of establishing Tier III indicators, while technical, may also be contingent on consensus being developed in other forums. For example, more than 50 per cent of the indicators for Goal 13 (climate action) are in Tier III. Currently available climate indicators are being used as proxies for monitoring the targets under Goal 13, while the UNFCCC process continues to develop modalities for measuring the targets.

In accordance with General Assembly resolution 71/313, the global indicator framework will be reviewed comprehensively by the Statistical Commission at its fifty-first session, to be held in March 2020. The 2020 comprehensive review will provide an opportunity to improve the indicator framework to advance the global monitoring of the Sustainable Development Goals.

Table 1-1
Projected distance from reaching selected targets by 2030 (at current trends)

GOAL	WITHIN 5%	5–10%	>10%	NEGATIVE LONG-TERM TREND
Goal 1		1.1. Eradicating extreme poverty	1.3. Social protection for all	
Goal 2		2.1. Ending hunger (undernourishment)	2.2. Ending malnutrition (stunting) 2.5. Maintaining genetic diversity 2.a. Investment in agriculture*	2.2. Ending malnutrition (overweight)
Goal 3	3.2. Under-5 mortality 3.2. Neonatal mortality		3.1. Maternal mortality 3.4. Premature deaths from non-communicable diseases	
Goal 4	4.1 Enrolment in primary education	4.6 Literacy among youth and adults	4.2. Early childhood development 4.1 Enrolment in secondary education 4.3 Enrolment in tertiary education	
Goal 5			5.5. Women political participation	
Goal 6		6.2. Access to safe sanitation (open defecation practices)	6.1. Access to safely managed drinking water 6.2. Access to safely managed sanitation services	
Goal 7		7.1. Access to electricity	7.2. Share of renewable energy* 7.3. Energy intensity	
Goal 8			8.7. Use of child labour	
Goal 9		9.5. Enhancing scientific research (R&D expenditure)	9.5. Enhancing scientific research (number of researchers)	
Goal 10			10.c. Remittance costs	Inequality in income*
Goal 11			11.1. Urban population living in slums*	
Goal 12				12.2. Absolute material footprint, and DMC*
Goal 13				Global GHG emissions relative to Paris targets*
Goal 14				14.1. Continued deterioration of coastal waters* 14.4. Overfishing*
Goal 15				15.5. Biodiversity loss* 15.7. Wildlife poaching and trafficking*
Goal 16			16.9 Universal birth registration **	

Note: Selected indicators only. SDG 17 is not included as it consists of a wide range of indicators that cannot easily be captured using the methodology for assessing distance from reaching targets. Estimates of the distance from the target by 2030 are based on forecasted value of the corresponding indicator in 2030, relative to target. Forecasts based on best-fit trends of individual indicators, given the available data range.

* Quantitative target for 2030 is not specified in the SDG indicator framework; targets are estimated.

** Assessment is based on indicators outside the SDG indicator framework; inequality in income is based on data from household surveys.

At the global level, table 1-1 and several other assessments (see box 1-4), as well as the 2019 Global Environment Outlook (GEO-6) assessment, the 2018 and 2019 Intergovernmental Panel on Climate Change (IPCC) reports, the 2019 Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) report and the latest report of the Committee for the Review of the Implementation of the Convention to Combat Desertification (CRIC), paint a similar picture that allow for broad conclusions.[36]

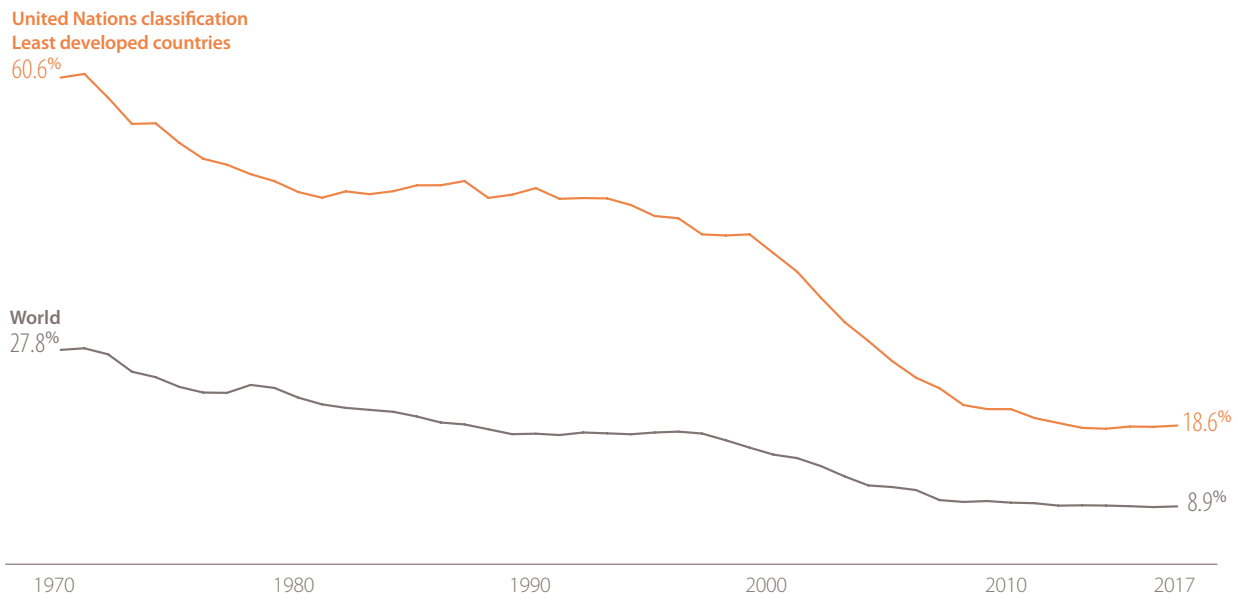
A straightforward read suggests that, at current rates of progress, several of the objectives of the 2030 Agenda should be attainable by 2030 – those depicted in table 1-1 as being within 5 per cent of the target –, including reducing child mortality and full enrolment in primary school. Other goals may also be reached with some additional effort – those depicted as being within 5 to 10 per cent of the target –, such as eradicating extreme poverty, ending hunger, ensuring universal access to electricity, eliminating open defecation, literacy among youth and adults, and desirable levels of expenditure on scientific R&D.

However, that straightforward projection ignores possible complexities. As targets are approached, rates of progress may start to slow, therefore predictions based on prior rates will be over-optimistic. For example, the World Bank's 2018 report on poverty found that in the 25-year period from 1990 to 2015, the extreme poverty rate fell, on average, at a rate of about one percentage point per year. However, in the period from 2013 to 2015, the rate fell to less than one percentage point.[37] A similar pattern can be seen with regard to primary school enrolment; an extended period of sharp decline began to level off as the ultimate objective of full enrolment was approached (see figure 1-3).

Such declines in rates of progress are apparent in other indicators, particularly when approaching a target of complete eradication. That may be because the populations being left behind are significantly harder to reach, or they suffer multiple deprivations that go beyond the specific Goal and that require action on other issues that are inherently intractable.[38] For example, Most of the people living in extreme poverty are increasingly concentrated in regions that combine multiple factors, including conflict, weak institutions and high population growth rates.[39] In such contexts, extraordinary efforts are needed to meet the Goals.[40]

A second group of targets are those where trends in the selected indicators are in the desired direction, but progress is too slow to meet the target. In table 1-1, for example, maternal mortality rates continue to fall, but progress is only at half the rate needed to achieve the target. The situation is similar for child malnutrition, access to safe drinking water and sanitation services, the share of renewables in the energy mix, early childhood development and enrolment in post-primary education. Other targets in that category include some of the necessary conditions for ending deprivations and reducing inequalities. For instance, the percentage of the population covered by social protection or birth registration is improving, but the rates of progress are clearly insufficient to meet the target of universal coverage.

Figure 1-3
Children out of school



Box 1-4
Other assessments of progress

Several authors have provided alternate assessments of the prospects for meeting the Sustainable Development Goals at the global, regional and country levels, with some using indicators that go beyond those in the global indicator framework. While methodologies and specific results vary, in general the alternate assessments agree that, based on current trends, many of the targets will not be met. For example, one study found that, of the 24 targets relating to health that are currently being measured, only 5 are likely to be met;[41] another reported that, 44 countries with populations exceeding 1 million, will not meet the goals for secondary education;[42] while yet another found that, of the 93 environment-related indicators, 22 are generally on track, but for the remaining 71, there is either insufficient data or trends point toward them not being met.[43]

At the regional level, one particular study looked at the likelihood of reaching each Goal in five main regions defined by the Organization for Economic Cooperation and Development (OECD) – the United States of America, OECD (excluding the United States), China, BRISE (Brazil, Russia, India, South Africa and ten other emerging economies) and ROW (rest of the world). It found that the United States, OECD and China regions were most likely to meet several of the Goals, such as those relating to hunger, health, education, clean water and sanitation, and industry, innovation and infrastructure. The BRISE and ROW regions were unlikely to meet any, but the BRISE region was more likely to be closer to the targets than the ROW region. All regions were likely to remain in the category of being furthest away from target for the Goals relating to inequality, responsible consumption and production,[44] and nature (climate, life on land, life on water).[45] Another study[46] found that the level of change needed to reach the Goals varied widely across developing regions and countries: sub-Saharan Africa was likely to be the furthest behind, with more substantial progress likely across South Asia, East Asia and the Pacific, and Latin America.

With regard to country-level assessments and forecasts, in 2019, one study found that no country was on track to meet all of the Goals by 2030. While data availability by country and by Goal varied, no Goal had more than 50 per cent of countries on track to reach it by 2030.[47]

Most worrisome, though, are the targets for which recent trends are not even in the right direction, either because implementation of the Goals has not yet been able to reverse pre-existing deterioration, or because world recovery from the 2008 economic crisis has brought back negative trends that had for the moment been stalled, such as obesity, inequality, greenhouse gas emissions, land degradation, biodiversity loss, wildlife trafficking, absolute material footprints, overfishing and deterioration of coastal waters. Several of those targets, for which even the direction of the trend is wrong, are of particular importance. Not only do they represent trends that are difficult to change, but they also make it harder to reach other Goals and targets, sometimes in ways that cascade across the entire 2030 Agenda.

Four trends, in particular, fall into that category: rising inequalities, climate change, biodiversity loss, and the increasing amount of waste from human activity that are overwhelming processing capacities. Critically, recent analysis suggests that some trends presage a move towards the crossing of negative tipping points, which would lead to dramatic changes in the conditions of the Earth system, in ways that are irreversible on time scales meaningful for society (see box 1-5).

Box 1-5
Tipping points

A tipping point is a critical point in an Earth system component, around which small perturbations can trigger an irreversible transition from one stable state to another. Transitions are not necessarily abrupt; but once begun can be impossible to reverse, and the eventual change is very dramatic. It is believed that such points exist for many components of the Earth system – such as the Arctic summer sea ice, the Greenland and Antarctic ice sheets, and the Amazon rainforest.

The dynamics can be illustrated by the Arctic summer sea ice, which is currently melting fast due to climate change. As the ice melts, more of the ocean area becomes darker and so absorbs more sunlight, which increases global warming and speeds up the melting. As a result, the Arctic is warming much faster than the rest of the world. The tipping point for the Arctic sea ice will be the critical temperature, after which the melting will become rapid and irreversible. Some estimate that it will take just 10 years for the ice to melt completely after the tipping point is reached.

The increase in greenhouse gases in the atmosphere and warming causing the melting of the Arctic sea ice may also have complex impacts on other systems, for example, the release of methane due to melting of permafrost will further exacerbate climate change; melting of the Greenland ice sheet; ocean circulation changes; ocean acidification; extreme weather events; and accelerated biodiversity loss.

Each of those impacts can lead to transitions in other components of the Earth system, in vicious feedback loops that would lead, through a cascade of transitions, to radically different states for many components. Those transitions would be irreversible on the time scales relevant for society. The exact point at which such transitions can be precipitated is difficult to estimate, but they are believed to be likely under many different scenarios.

The Earth system could likely be kept in its current state by actions such as reducing greenhouse gas emissions and strengthening carbon sinks to achieve net-zero emissions. However, the time window within which such actions need to occur could be a short one.[48]

1.2.2. Regions and population groups

Individual countries, as well as their groupings along regional or other parameters, can differ significantly in the challenges they face toward achieving the Sustainable Development Goals. Those challenges will only be described very briefly in this Report; more detailed treatments are available in regional Sustainable Development Goals reports and the voluntary national reviews.

See for example the special challenges faced by small island developing States (box 1-6) and least developed countries (box 1-7).

Box 1-6
Small island developing States[49]

Starting in 1992, the United Nations consider small island developing States (SIDS) as special cases for sustainable development owing to their unique combination of vulnerabilities – whether they are located in the Caribbean, or in the Pacific, Atlantic or Indian Oceans. Their defining features include:

- Small size;
- Remoteness from global market centres;
- Undiversified economies and resulting susceptibility to economic shocks and high debt load;
- Immediacy of climate change impacts, including sea-level rise, salt-water encroachment, ocean acidification, and more frequent and intense storms.

Many small island developing States have relatively high per capita GDPs, which can hinder their access to concessional financing and other development assistance. However, because of their structural challenges, many have been calling for the use of criteria beyond GDP, when deciding on eligibility.

Small island developing States have also been at the forefront of the fight against climate change. Some States have acted as moral leaders in the push for more ambitious mitigation targets, holistic and innovative approaches to climate adaptation, and compensation for loss and damage.

Another hurdle facing small island development States is the lack of high-quality, disaggregated data. Even when the data exist, the small size of their populations often makes it difficult to use standard data metrics to track progress on a variety of Sustainable Development Goals indicators.

The most common challenges faced by small island development States are:

- Climate variability and sea-level rise
- Little resilience to natural hazards
- Constraints in terms of both the quality and quantity of freshwater
- Narrow resource base that deprives them of the benefits of economies of scale
- Small domestic markets and heavy dependence on a few external and remote markets
- High fixed costs for the public sector and high per capita costs for civil infrastructure
- Low and irregular international traffic volumes
- High volatility of economic growth
- Limited opportunities for the private sector and a correspondingly large economic reliance on the public sector
- Fragile natural environments
- Vulnerability to fluctuations in price or availability of food imports
- High indebtedness and constrained fiscal space

Box 1-7
Least developed countries[50]

The 2030 Agenda is a universal undertaking, adopted by all 193 United Nations Member States and representing a global commitment to transform our world. However, certain groups of countries face particular challenges that require redoubled engagement and support from the international community. The least developed countries are the 43 Member States with the highest levels of poverty and deprivation in the world. Their vulnerability can be seen across all the Sustainable Development Goals.

The least developed countries are home to 12 per cent of the global population, but account for only 2 per cent of global GDP and 1 per cent of global trade. Their growth in GDP per capita was 4.5 per cent in 2017, and is projected at 5.7 per cent in 2020, which is below the 7 per cent called for in the 2030 Agenda. Least developed countries often rely on a limited number of commodity exports, which makes them extremely vulnerable to shocks, and they are currently off track in relation to the Goal 9 target to double the manufacturing industry's share of GDP by 2030. The shortfall is especially severe in the medium- and high-technology sectors. Those sectors represent 47.4 per cent of manufacturing production in North America and Europe, but only 10.4 per cent in least developed countries.

The least developed countries lag behind other groups of countries in many other targets as well. For example, they have higher rates of neglected tropical diseases, and physical and/or sexual partner violence, lower numbers of medical personnel and women in management positions, lower rates of Internet access and access to pre-primary education. Individuals in least developed countries are less likely to have access to electricity (51 per cent in 2017, while the global rate was 88.8 per cent) or to a basic handwashing facility at home (34 per cent, while the global rate is 60 per cent).

Nonetheless, there is scope for optimism. The Technology Bank for Least Developed Countries, established in 2018, following the call in the Istanbul Programme of Action for the Least Developed Countries and the 2030 Agenda, is working to make science, technology and innovation resources available to institutions and individuals in least developed countries and to strengthen the science, technology and innovation ecosystem in least developed countries. Furthermore, least developed countries are taking strong steps in the climate action arena. At the twenty-second Conference of the Parties (COP 22) to the United Nations Framework Convention on Climate Change, held in Marrakech, Morocco in 2016, 24 least developed countries, members of the Climate Vulnerable Forum, announced that they would transition to 100 per cent renewable energy by 2050.

At the regional level also, certain broad characteristics are evident. In Africa, targets related to poverty, food security, maternal health and education are among the greatest challenges.[51] There is also a growing youth population seeking employment, but opportunities are limited – between 10–12 million youth seek to join the labour force each year, vying for only about 3.7 million jobs.[52, 53]

In the Arab region, challenges relate to ongoing conflicts in the Syrian Arab Republic and Yemen that have raised the region's poverty rate, increased food insecurity and worsened human development.[54, 55, 56] The region also contains 14 of the world's 20 most water-stressed countries. Youth unemployment surpasses 30 per cent, reaching 48 per cent among young women.[57]

The Asia-Pacific region has made progress with regard to poverty eradication, high-quality education, and affordable and clean energy.[58] The majority of countries in the region have already achieved, or are close to achieving, universal primary education.[59] The challenge there may be to reach those groups who, despite progress, are most at risk of being left behind as well as to accommodate an ageing population structure.

In South Asia, progress has been slow in areas like gender equality, and the region has taken some steps back in areas such as clean water and sanitation, decent work, economic growth, and responsible consumption and production.[60]

In Europe and other developed regions, countries face challenges in reducing carbon dioxide emissions, with emissions per capita remaining much higher than global averages. Countries also need to manage demographic transitions and inequalities, including closing gender gaps in labour participation and wages. Declining labour shares of GDP are also noticeable across wealthy countries, linking to growing inequality.[61]

Trends vary across population groups. Individual population groups, such as women and girls, youth, persons with disabilities and indigenous peoples,

among others, continue to suffer systemic deprivations. Gender inequality persists throughout the life cycle – girls have fewer opportunities for learning at school, especially in the sciences; women face barriers in the labour market with lower wages and lower labour force participation rates; and older women – who are expected to live 3 years longer than men, on average – are more affected by a lack of long-term care protections.[62, 63, 64]

Data indicate that women spend about three times as many hours in unpaid work as men.[65] Labour force participation rates in paid work are lower for women (48.7 per cent) than for men (75.3 per cent), and unemployment rates are higher for women compared to men at a ratio of 1.24.[66] Furthermore, opportunities for women and girls are limited by norms such as childhood marriage (which affects 650 million girls and women today); female genital mutilation (which affects 1 in 3 girls aged 15 to 19 in countries where it is practised); and the threat of physical and/or sexual violence (which affects 20 per cent of girls aged 15 to 19 in countries with data).[67] Accelerating progress toward the Sustainable Development Goals for women and girls would empower half the world's population, and significantly close remaining gaps in achievement.

More than one billion people in the world today (an estimated 15 per cent of the world population)[68] experience some form of disability. Persons with disabilities face various forms of exclusion, and generally have poorer health, lower education achievements, fewer economic opportunities and higher rates of poverty than people without disabilities. This is largely due to the lack of services available to them and the many obstacles – including negative attitudes, beliefs and prejudices – that they face in their everyday lives. Thirteen years after the adoption of the Convention on the Rights of Persons with Disabilities, in 2006, progress in its practical implementation remains far too limited.[69]

Indigenous peoples number over 370 million in some 90 countries (2009 estimates), yet their situation in many parts of the world continues to be critical. They often face discrimination and exclusion from political and economic power, with disproportionately high rates of poverty, ill health, poor education and destitution. Additional challenges include dispossession of ancestral lands and the threat of extinction of traditional languages and identities.[70]

1.2.3. Rising inequality

The entire 2030 agenda is threatened by rising inequalities in income and wealth. Since 1980, notwithstanding some gains at the lowest parts of the income distribution of the global population, income inequality has risen sharply. Although the poorest 50 per cent of the world population did see incomes rise significantly (primarily due to high growth in Asia), they only received a 12 per cent share of the global gains, while the richest 1 per cent of the world population received 27 per cent.[71] Growing wealth and income inequality has been primarily driven by concentration at the top. In the 1980s, the richest 1 per cent of the world population had 28 per cent of total wealth, but by 2017, they had 33 per cent, while the bottom 75 per cent had stagnated around only 10 per cent.[72] For individuals caught between the two extremes – primarily the middle classes in Western Europe and the United States – the period was marked by, at best, sluggish income growth.[73] The skewed nature of the gains is represented in figure 1-4.

The increase in income share at the top of the global income distribution is related to several other factors. In the United States, for example, while the productivity of workers has doubled since the 1980s, almost all the gains have gone to executives, owners and investors, while wages for those in production or non-supervisory jobs have stagnated.[74, 75] Several factors have contributed to that trend, including globalization, automation, the declining influence of unions, and stagnant federal and state minimum wages. That has led to a substantial hollowing-out of the labour market, with job creation primarily at the high- and low-skill ends.

Increasing inequalities are also apparent in other countries and regions. Researchers have observed an increasing concentration of income in a range of countries with the top 10 per cent trending towards a high-inequality frontier with a Gini-coefficient of over 60.[76] In parallel, while income across countries appeared to be converging over the period from 2000 to 2010, such movement has slowed or even reversed in recent years, especially in sub-Saharan Africa compared to the rest of the world.[77]

The relationship between inequality and well-being is complex. Current levels of inequality in income or wealth can represent historical patterns in the distribution of assets or opportunities. At the same time, they may also connect to future-oriented behaviour – retaining monopoly positions, on the one hand, while motivating individual efforts, on the other. There is no scientific consensus on what would be optimal for the Sustainable Development Goals, but there is mounting evidence that current levels and trends present challenges. Several streams of research indicate the mechanisms through which those challenges are manifested.

Figure 1-4:
Global inequality and growth, 1980–2016

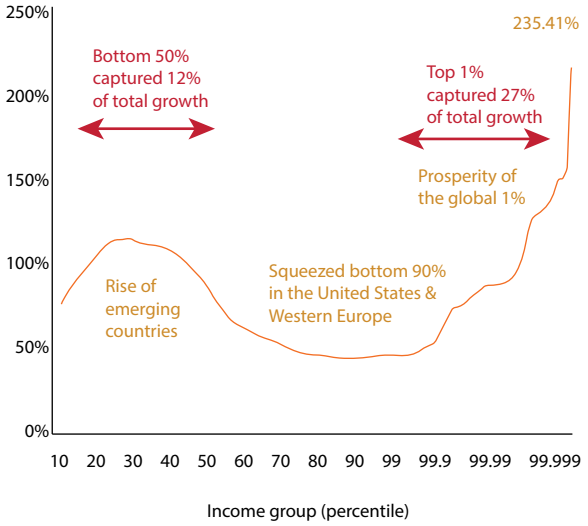
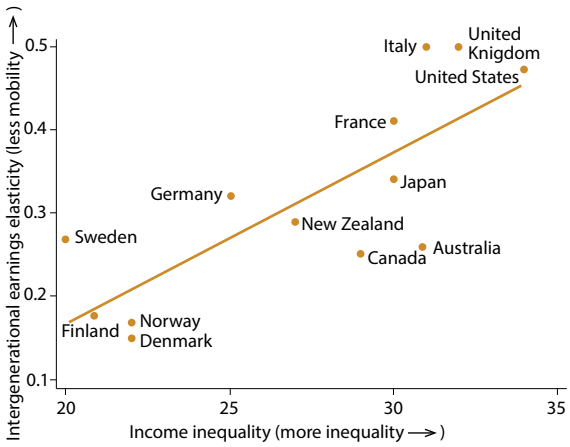


Figure 1-5
Intergenerational mobility and inequality



Rising inequalities in income and wealth can indicate inequalities in opportunity, such as unequal access to good-quality childhood nutrition, education, health care or societal discrimination. At sufficiently high levels, inequality also represents challenges to intergenerational mobility. Inequalities can become self-perpetuating, for example through inherited wealth or exclusive access to high-quality education and skills.[78] In the United States, roughly one half of the inequality that existed during the parents' generation is passed on to the children. However, public policies can be important drivers of social mobility in countries like Germany or Denmark, where only one fifth and one sixth, respectively, of income inequality is transmitted between generations.[79]

That relationship can be demonstrated by plotting measures of intergenerational mobility against income inequality for a group of rich countries (see figure 1-5).[80] Known as the Great Gatsby Curve, the graph shows how, as inequality rises, intergenerational mobility falls.[81, 82]

Rising intra-country inequality also threatens progress more broadly, making economic growth slower and more fragile. As people with less education and poorer access to healthcare work below their full potential, social instability can rise, further deterring investment and reducing the capacity to recover from shocks.[83] Poor access to good-quality health care widens inequalities in health outcomes, and lower socioeconomic status in unequal societies contributes to worsening health through increasing and sustained stress levels. It is well documented that stress has biochemical effects on the body throughout life.[84, 85]

Greater inequality can also affect the environment, as those at the upper end of the income distribution may be able to shift the environmental costs of their lifestyles and consumption decisions to those at the lower end. That can occur at both the national and international levels.[86, 87] Such shifts occur at the global scale in the case of climate change: the top 10 per cent of emitters contribute to about 45 per cent of global carbon dioxide emissions, while the bottom 50 per cent of emitters contribute to 13 per cent of global emissions. Similar unequal patterns are also apparent at national and subnational levels.[88]

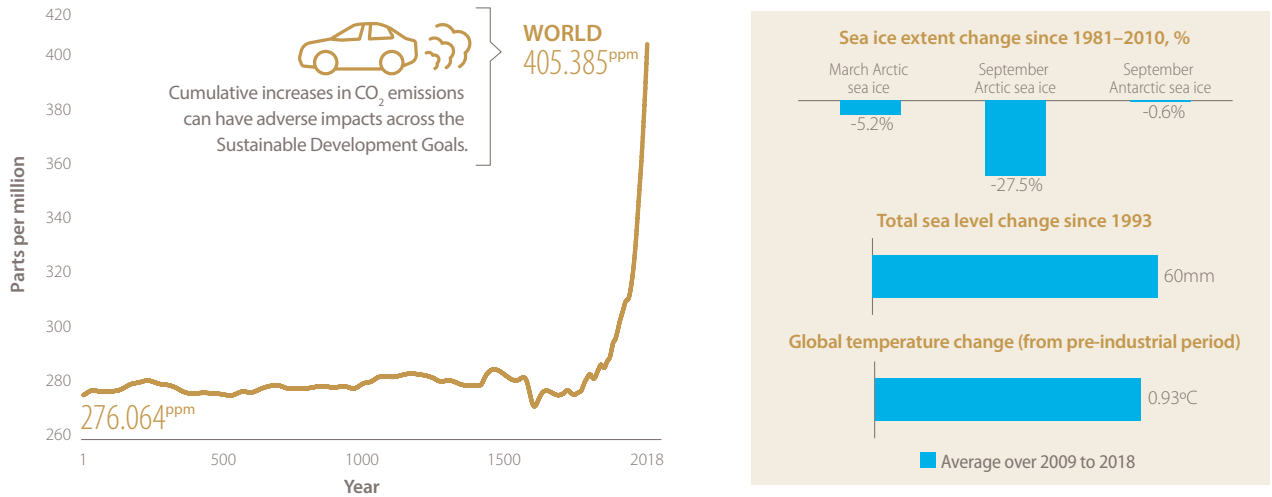
Those at the bottom of the income distribution are also more at risk of facing the consequences of degraded environments and biodiversity loss. The recent GEO-6 assessment noted that the livelihoods of more than 70 per cent of the world's poor are natural resources based. Globally, 29 per cent of land is already degraded, affecting the lives and livelihoods of 1.3–3.2 billion people, and in some cases leading to migration and even conflict.[89]

Inequality may have broader negative impacts when the efforts by those at the top to maintain their positions divert resources from accelerating the transformations that are needed to achieve the 2030 Agenda.

1.2.4. Climate change

Since the industrial revolution, human activities have increased atmospheric concentrations of greenhouse gases, primarily CO_2. Their presence in the atmosphere has already warmed the Earth by a mean average temperature of about 1°C. Emissions are once again on the rise globally, and if current trends continue, global warming is set to cross the 1.5°C benchmark between 2030 and 2052.[90]

Figure 1-6:
Human activity induces climate change: rising CO_2 levels, increasing mean temperatures, shrinking sea ice, elevated sea levels



The impacts of planetary warming are already apparent. Over the past decade, a large number of countries have registered their warmest-ever years. Extreme events such as hurricanes, floods and forest fires have also become more severe.

Even a temperature rise limited to 1.5°C above pre-industrial levels could damage the prospects for the Sustainable Development Goals,[91] and put pressure on 500 million people exposed and vulnerable to water stress, 4 billion people exposed to heat waves, and tens of millions of people exposed to coastal flooding. A 1.5°C temperature rise would also reduce agricultural yields and increase the levels of species extinction.[92, 93] Should the actual temperature rise be higher, the scale of devastation would be worse. Based on current policies and pledges, human-caused global warming is estimated to exceed 3°C by the end of this century. [94]

The Intergovernmental Panel on Climate Change (IPCC) report on limiting global warming to 1.5°C above pre-industrial levels considered different scenarios for reaching that objective:[95] all require net zero CO_2 emissions by 2050 and concurrent deep reductions in non-CO_2 greenhouse gas (particularly methane) emissions, with global reductions beginning soon. The scenarios studied were all consistent with the continuing improvement in people's lives across the globe but differ markedly in how the reductions in emissions will be achieved.

One scenario is a pathway that assumes a continuing widespread adoption of greenhouse-gas-intensive lifestyles, with high demand for transportation fuels and livestock products. Achieving the global warming target (with a significant overshoot above 1.5 ° C warming) would only be possible through a rapid and large-scale deployment of technologies that remove CO_2 from the atmosphere. However, although technologies that can do so are under development, none as yet exist at the scale needed for the required impact. Most of those technologies could have significant impacts on land, energy, water or nutrients if deployed at large scale, and may have significant impacts on agricultural and food systems, biodiversity, and other ecosystem functions and services. In this scenario, final energy demand in 2030 is 39 per cent higher than in 2010, and agricultural methane emissions are 14 per cent higher over the same time period.

Another scenario assumes that improvement in people's lives must be accompanied by lifestyle changes that lower total energy demand, while also reducing the land and greenhouse-gas intensity of food consumption. Social, business and technological innovations would generate services with far lower total energy use, while diets across the world would move towards better nutrition, with improved agricultural productivity, and preferences for less livestock-intensive foods that would lead to change.[96] This scenario relies on the removal of much smaller amounts of CO_2 – that can be managed within natural forest and land use systems, without the need to develop, validate and deploy new technologies at scale. In this scenario, final energy demand and agricultural methane emissions in 2030 are 15 per cent and 24 per cent lower, respectively, than in 2010.

1.2.5. Rising waste production

Waste, the by-product of human activity, threatens progress towards sustainable development when collective processing capacities are overwhelmed.

Waste comes in many forms: gaseous – such as greenhouse gases leading to climate change, liquid and solid. Much of the current solid waste production is in the form of plastics. Large-scale plastics production began in the early 1950s, and by 2015, humans had generated 8.3 billion metric tons of plastics, of which 6.3 billion tons ended up as waste. Of that amount, only 9 per cent was recycled, while 12 per cent was incinerated, and 79 per cent was deposited in landfills or in the natural environment.[97] In 2010 alone, 8 million tons of plastic were dumped into the ocean, threatening the well-being of marine life. Beyond the ecological consequences, plastic waste also causes immense economic damage.[98] In the Asia-Pacific region alone, plastic litter costs $1.3 billion a year in the tourism, fishing and shipping industries.[99] Worldwide, the total damage to the world's marine ecosystem is estimated at least at $13 billion annually.[100]

Those trends show no signs of slowing down. The volume of plastic-waste production could grow from 260 million tons per year in 2016 to 460 million tons by 2030.[101] Nearly half of that comes from packaging materials. Plastic packaging can increase resource productivity by extending the shelf life of food, and because it is light, less fuel is consumed during transportation. However, close to half of single-use packaging ends up in landfills or leaks out of formal waste collection systems, with devastating consequences for the environment.[102]

Another major concern in terms of solid waste is electronic waste, or e-waste, which is growing faster than any other type of refuse. Between 2014 and 2016, the generation of e-waste increased by 8 per cent to 43 million tons per year. By 2021, the annual total could be 52 million tons,[103] driven partly by shortening product cycles. In the United States, China and major European Union economies, the average lifecycle of a smartphone is between 18 months to 2 years.[104]

In 2016, the value of recoverable materials, such as gold, silver and aluminium, in global e-waste was estimated at $64 billion, but only about 20 per cent of e-waste was properly recycled. Around 60 per cent ended up in landfills, where elements like mercury and lead can leak into soil and groundwater.[105] Both plastics and e-waste can, even when produced and consumed in developed countries, can end up in the landfills or recycling processes in developing countries. Even recycling valuable e-waste can be harmful. In developing countries, e-waste collection and recycling is often done informally by self-employed individuals, who often do not wear protective equipment and/or are unaware that they are handling hazardous materials. After informal door-to-door collection, many electronic products are recycled using substandard methods that could be hazardous to human and environmental health. Children are especially vulnerable to e-waste exposure as their central nervous, immune and digestive systems are still developing.[106]

A number of countries are taking action in response to the pressures and devastating consequences of plastic and electronic waste. In Bangladesh, where plastic bags were choking drainage systems during severe floods, the Government was the first worldwide to ban their use in 2002. In 2008, Rwanda and China issued policies to reduce the number of plastic bags in circulation: in China, the number fell by around 40 billion in just one year.[107] Several countries are banning, or planning to restrict, the use of various plastics products.

Countries in Latin America are taking steps to regulate e-waste. Colombia has adopted a national system for the collection and management of e-waste.[108] As of 2017, seven countries (Bolivia (Plurinational State of), Chile, Colombia, Costa Rica, Ecuador, Mexico and Peru) have been enforcing national legislation on e-waste, while four others (Argentina, Brazil, Panama and Uruguay) had embarked upon the process of adopting similar rules. Between 2014 and 2016, the proportion of the world population covered by national e-waste management regulation increased from 44 to 66 per cent.[109]

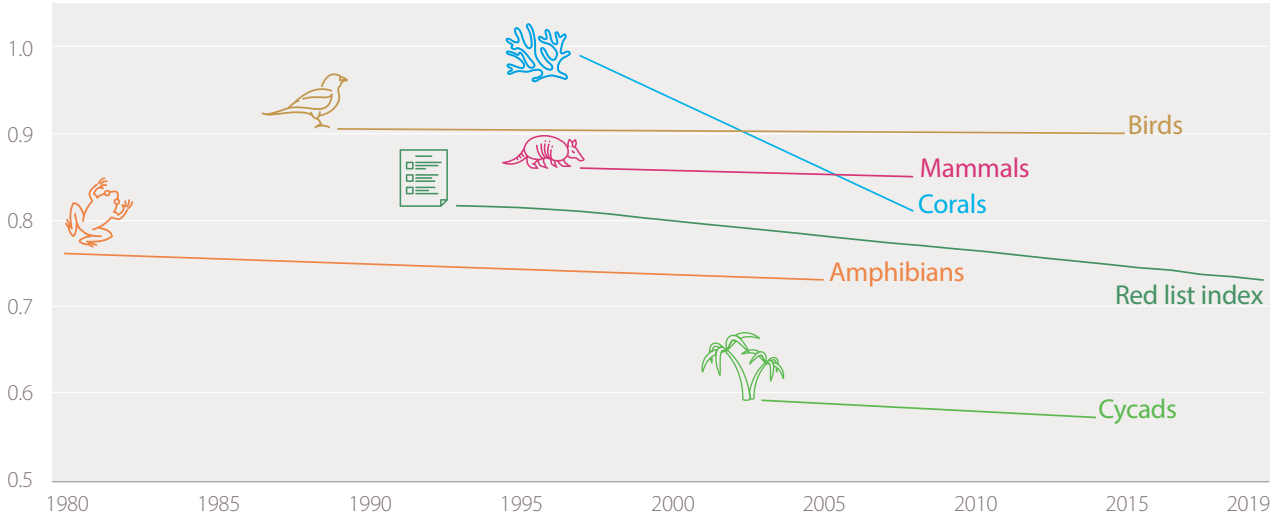
1.2.6. Biodiversity loss

Ultimately, the state of the Earth system is determined by the interaction between all living organisms (the biosphere) and the non-living physical systems. Biodiversity is therefore critical to the maintenance of the Earth conditions that support humanity. Biodiversity is also critical to ecosystem health and stability.[110] Sustainable development relies on resilient and biodiverse ecosystems that support household livelihoods, food production and the availability of clean water, while also promoting climate change mitigation and resilience. The diversity of species on land and in the ocean plays a key role in ecosystems and their provisioning, regulating and supporting services. However, as pointed out in the 2019 global assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), the rate of loss of species and genetic resources experienced over the past decades may lead to a sixth mass extinction if immediate action is not taken. About a quarter of the species in assessed animal and plant groups are threatened, suggesting that nearly 1 million species already face extinction – many within decades –, unless action is taken to reduce biodiversity loss. If not, there will be a further acceleration in the global rate of species extinction, which is already at least tens

to hundreds of times higher than averaged over the past 10 million years.[111] Animal pollinators, for example, account for up to $577 billion of global crop production worldwide, and contribute to the production of medicines, fibres and biofuels, as well as to the quality of culture and recreation.[112] According to IPBES estimates, pollinators of 75 per cent of crops are being threatened. The overall biodiversity picture across all global regions is grim[113] (see figures 1-7 and 1-8).

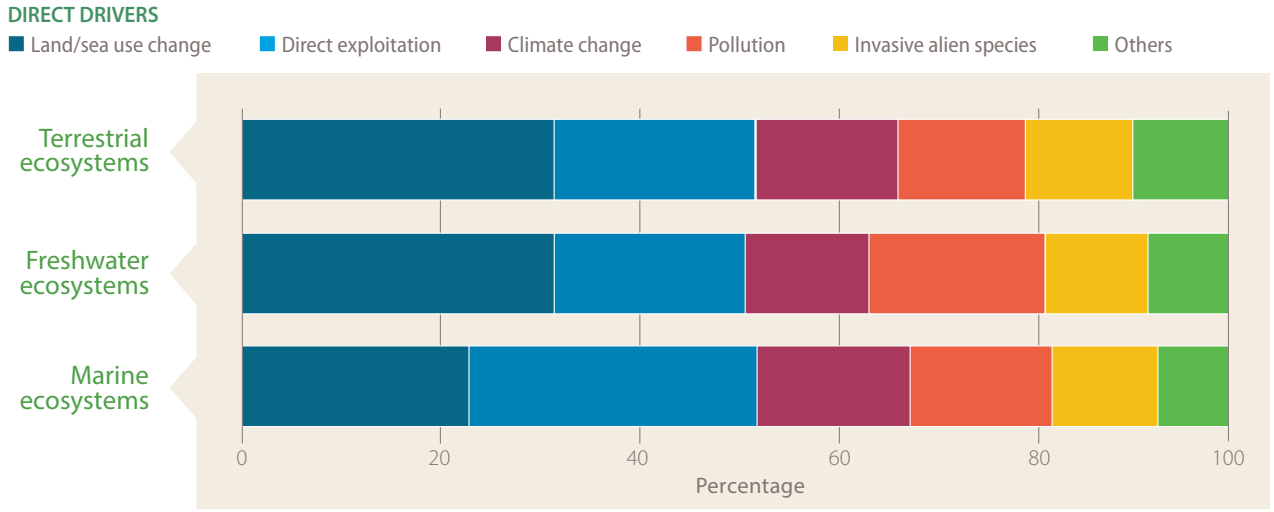
Globally, local varieties and breeds of domesticated plants and animals are disappearing. Loss of diversity, including genetic diversity, poses a serious risk to global food security as it undermines the resilience of agricultural systems to pests, pathogens and climate change. This unprecedented loss of biodiversity is driven by several interrelated factors: change in land and water use, overexploitation of resources, climate change, pollution and emergence of invasive species (see figure 1-7). It is likely that most of the Aichi Biodiversity Targets for the period 2011–2020, adopted at the tenth meeting of the Conference of the Parties to the Convention on Biodiversity, held in Aichi Prefecture, Japan, in October 2010, will be missed, although supporting conservation of biodiversity for future generations is key for sustainable development.

Figure 1-7
Continuing loss of species



Note: The Red List Index (RLI) shows trends in overall extinction risk for species with extinction at an index of zero.

Figure 1-8
Human activities drive biodiversity loss



1.3. Knowledge-based transformations for sustainable development

The Sustainable Development Goals are characterized by three signature elements: balancing the economic, environmental and social dimensions of sustainable development; leaving no one behind; and ensuring the basic requirements for the well-being of future generations. All those elements are at risk of not being realized. Recent assessments show that, under current trends, the world's social and natural biophysical systems cannot support the aspirations for universal human development that is embedded in the Goals. [114]

No country is yet convincingly able to meet a set of basic human needs at a globally sustainable level of resource use.[115] This is illustrated in figure 1-9, which shows the status of countries according to the extent to which they are meeting social thresholds – that is, minimally acceptable levels of individual and social well-being along multiple dimensions –, while transgressing biophysical boundaries – that is, multidimensional assessments of environmental impact.[116] Most of the richer countries are clustered in the top right quadrant, while poorer countries are in the bottom left quadrant. The ideal position – based on national averages – but neglecting intracountry distributions – is the top left quadrant, where countries would be meeting or exceeding social thresholds without transgressing biophysical boundaries.

Other formulations also capture this imperative for people and planet to move towards a fundamentally different endpoint: some are national, such as the ecological footprint relative to the human development index; others are subnational, such as indicators at the provincial level.[117] These formulations complement evidence presented earlier on the overlapping nature of multiple deprivations and the concentration of populations that are deprived in this manner within specific geographic areas and among particular groups. It is clear that a business-as-usual scenario will not achieve many of the Sustainable Development Goals and may not even be a guarantee against backsliding.

The currently available evidence shows that no country is on track in reconfiguring the relationship between people and nature in a sustainable manner. All are distant in varying degrees from the overarching target of balancing human well-being with a healthy environment. Each country must respond to its own conditions and priorities, while breaking away from the current practice of growing first and cleaning up later. The universal transformation towards sustainable development in the next decade depends on the simultaneous achievements of individual innovative pathways that manage to make that break.

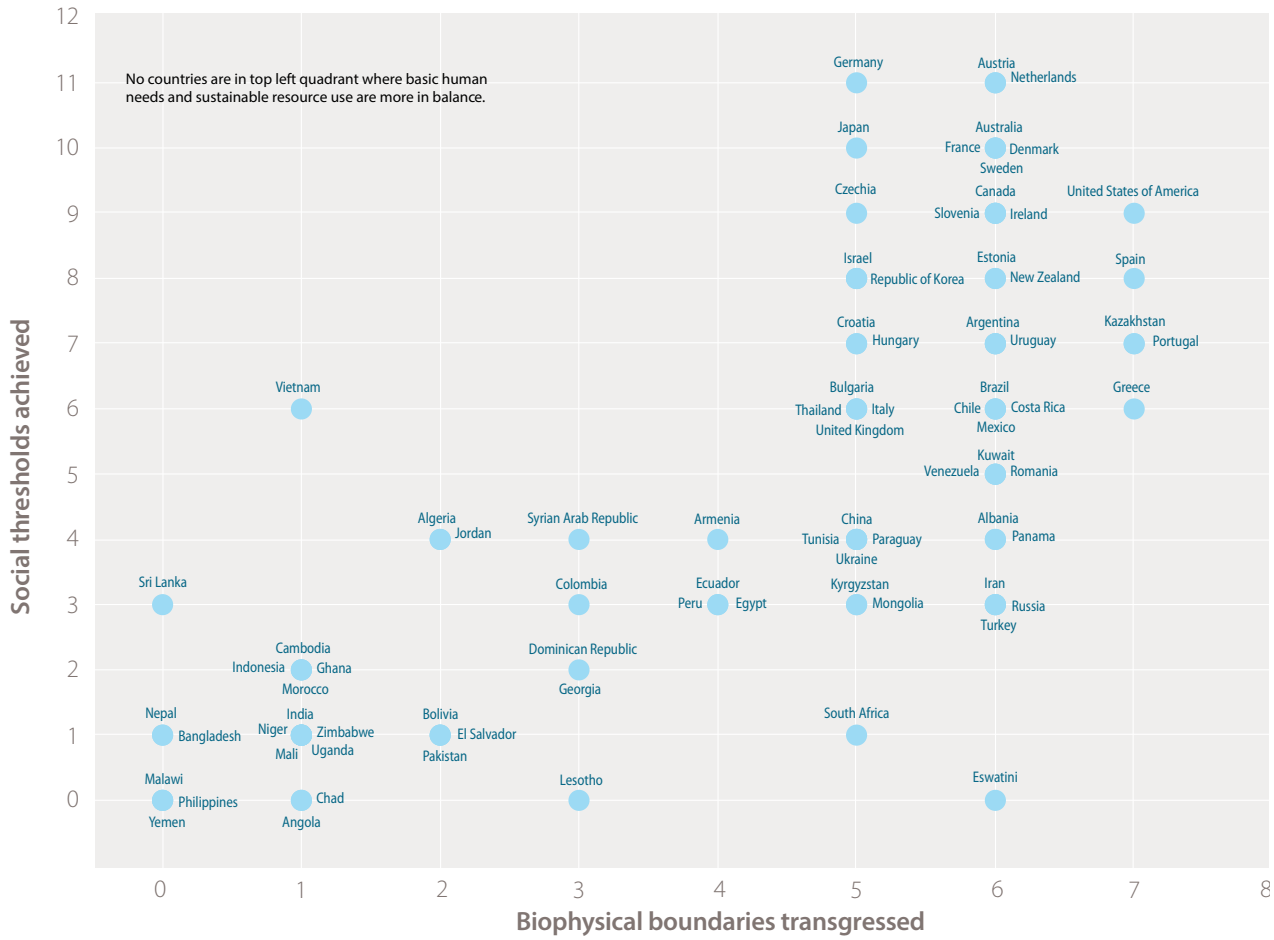
There is reason for hope: human well-being need not depend on intensive resource use. One study found considerable variation in levels of biophysical resource use across countries that had successfully crossed identified social thresholds – a number of countries had done so while staying within biophysical boundaries.[118, 119] Indeed, there were best-case examples for almost all of the social thresholds, which demonstrate that it is possible to advance human development within the sustainability limits of impacting nature.

In order to accelerate progress in that way, a more integrated approach that addresses multiple goals simultaneously is needed, rather than narrow, sectoral approaches that focus on one or an excessively narrow subset of goals at a time. The more efficient – or even the only – way to make progress on a given target is to take advantage of positive synergies with other targets while resolving or ameliorating the negative trade-offs with yet others.

An important key to doing that is to recognize that, while the present state of imbalance across the three dimensions of sustainable development arises from not having fully appreciated the interlinkages across them or having unduly prioritized the short term, it is those same interlinkages that will lead to the desired transformative change, when properly taken into account. Translating that insight into practical action for the Sustainable Development Goals needs to be informed by knowledge that emphasizes the need for urgency, forward-looking expectations about a growing global population seeking higher levels of well-being, and normative considerations such as leaving no one behind. That basic understanding has guided this Report's concept and structure, leading to its identification of knowledge-based transformations for sustainable development (see box 1-8).

Accordingly, the present Report identifies six entry points that offer the most promise for achieving the desired rebalancing at the scale and speed needed for the 2030 Agenda. These are not entry points into

Figure 1-9
Striking the balance: no country is meeting basic human goals within biophysical boundaries



individual or even clusters of SDGs, but rather into the underlying systems. At the same time, not attending to the interlinkages that are intrinsic to the entry points, as well as across them – for example, through focusing on individual Goals and targets – would imperil progress across multiple elements of the 2030 Agenda.

The six entry points are:

- Human well-being and capabilities
- Sustainable and just economies
- Food systems and nutrition patterns
- Energy decarbonization and universal access
- Urban and peri-urban development
- Global environmental commons

Human well-being and capabilities: This is key to the overarching mission of eradicating poverty in all its forms and manifestations and reducing inequalities to leave no one behind. However, we are at risk of not succeeding due to inequalities in opportunities; persistent gender inequality; mismatches between education and skills, especially looking to the future; unequal access to health care, exposure to disease, and attainment of high standards of health; insufficient resilience to recover from shocks; and inadequate preparation for dealing with ageing. Many of the needed transformations in this area are demonstrably possible within more balanced economic paths.

Sustainable and just economies: Economic activity provides livelihoods, jobs, incomes and the means to attain many other elements of a better life, however, current production and consumption systems also threaten the well-being of present and future generations through increasingly negative impacts on the environment and, in many cases, inequality. Such trends seem set to continue. A fundamental reconfiguration is needed in the production and consumption of goods and services, guided by a lowered environmental footprint and greater distributional justice. Moreover, national and international financial systems must be aligned to the Sustainable Development Goals. Achieving the 2030 Agenda for sustainable development will require leadership from both the public and the private sector,

targeted policy interventions, and shifts in social and lifestyle norms.

Food systems and nutrition patterns: This is essential for sustenance and health, yet current practices along the entire food production and consumption chain lead to unsustainable resource use, biodiversity loss, land degradation, river and ocean pollution, climate change, undernutrition, as well as obesity and non-communicable diseases.

Energy decarbonization and universal access: Energy is key to economic growth, poverty eradication and the realization of human potential, but it is also the single largest contributor to climate change and particulate air pollution, as well as other negative impacts on people and the planet. At the same time, many people do not have access to energy. Technologies exist for moving towards universal access and increased efficiency along decarbonized pathways, but major difficulties persist in achieving adoption at scale.

Urban and peri-urban development: More than half the world's population already live in urban areas and that number is growing, offering the opportunity to achieve multiple Goals at scale and with efficiency, provided synergies are realized and trade-offs avoided. Areas of concern include unsustainable natural resource use, large volumes of waste, and stark inequalities. Decisions on urban and peri-urban infrastructure investment can lock populations into unsustainable development for the very long term.

Global environmental commons: This is essential for the overall balance between nature and humanity. Natural systems are interconnected on a global scale and affected by actions at all levels that have implications across the world. Achieving transformation in the entry points would help to secure the global environmental commons. However, the entry points alone may not be sufficient, especially if actions do not adequately address global interconnections or take full account of the non-economic, but intrinsic value of nature.

The Report also identifies four levers:

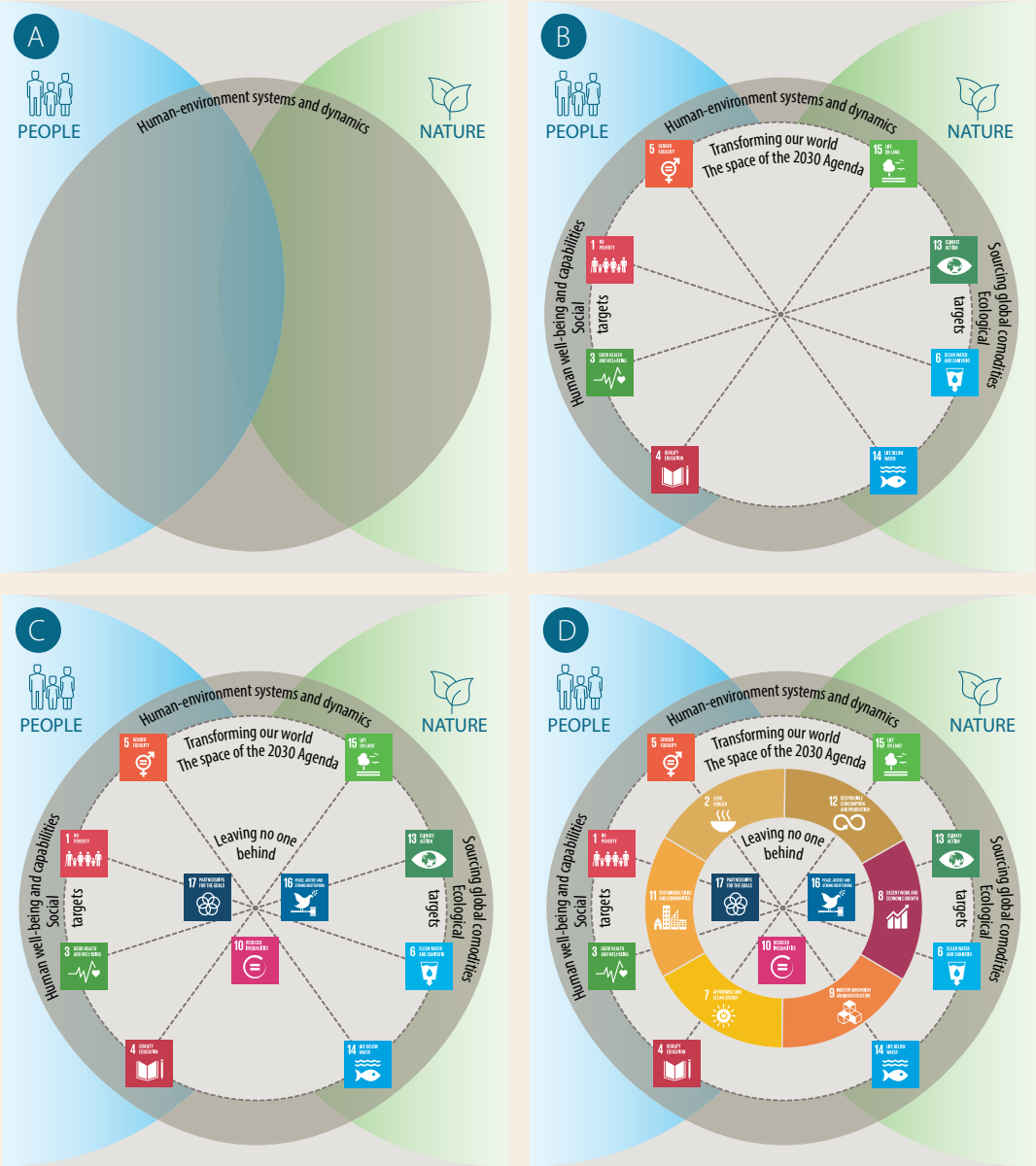
- Governance,
- Economy and finance,
- Individual and collective action, and
- Science and technology.

The levers can be deployed to bring about the necessary transformations through each entry point. They are related to the means of implementation characterized in Goal 17 but are also different in that they accommodate the multiple, complementary roles that individual actors and entities play in bringing about change. For example, engineers develop technology solutions (included in the science and technology lever) but can also collaboratively set standards for ethical applications of advanced technologies (as part of both the governance and the collective action levers).

Each of the levers can contribute to systemic change, however, in this Report, it is argued that only through their context-dependent combinations will it be possible to achieve the transformations necessary for balancing across the dimensions of sustainable development and achieving the 2030 Agenda. The role of the levers will be discussed further in the following chapter.

Box 1-8

The Global Sustainable Development Framework for knowledge-based transformations towards sustainable development



Progress in human well-being is closely connected to the state of the natural environment, and vice versa. The space for moving to a sustainable development trajectory lies at the interface between these two components of the Earth System (panel A). Currently, however, the world is not set on a trajectory that lies within this space.

The 2030 Agenda for Sustainable Development defines a political space within which United Nations Member States have committed themselves to managing both the relationships among human beings and between human activities and the planet. That space is delineated by a set of social targets that define human well-being and capabilities, as well as environmental targets to secure nature and the global commons (panel B).

As those social and environmental targets are intractably linked, it is not possible to carry out one intervention without influencing another. Therefore, choices need to be made with respect to balancing the gains and trade-offs of all activities. The overarching objectives provide essential guidance for making choices (panel C).

Achieving more equitable and balanced development within the political space of the 2030 Agenda is possible only by engaging with the systems that connect people and nature to their guiding goals (panel D).

Chapter II

Chapter II

Transformations

The 2030 Agenda proposes a plan of action that does not just indicate the world's aspirations for 2030, but also outlines steps towards achieving transformation. Taking a systemic perspective on the Sustainable Development Goals and their interactions, the present Report identifies six key entry points for successful transformations towards sustainable development, and four levers that are critical to maximizing impacts in different parts of the world.

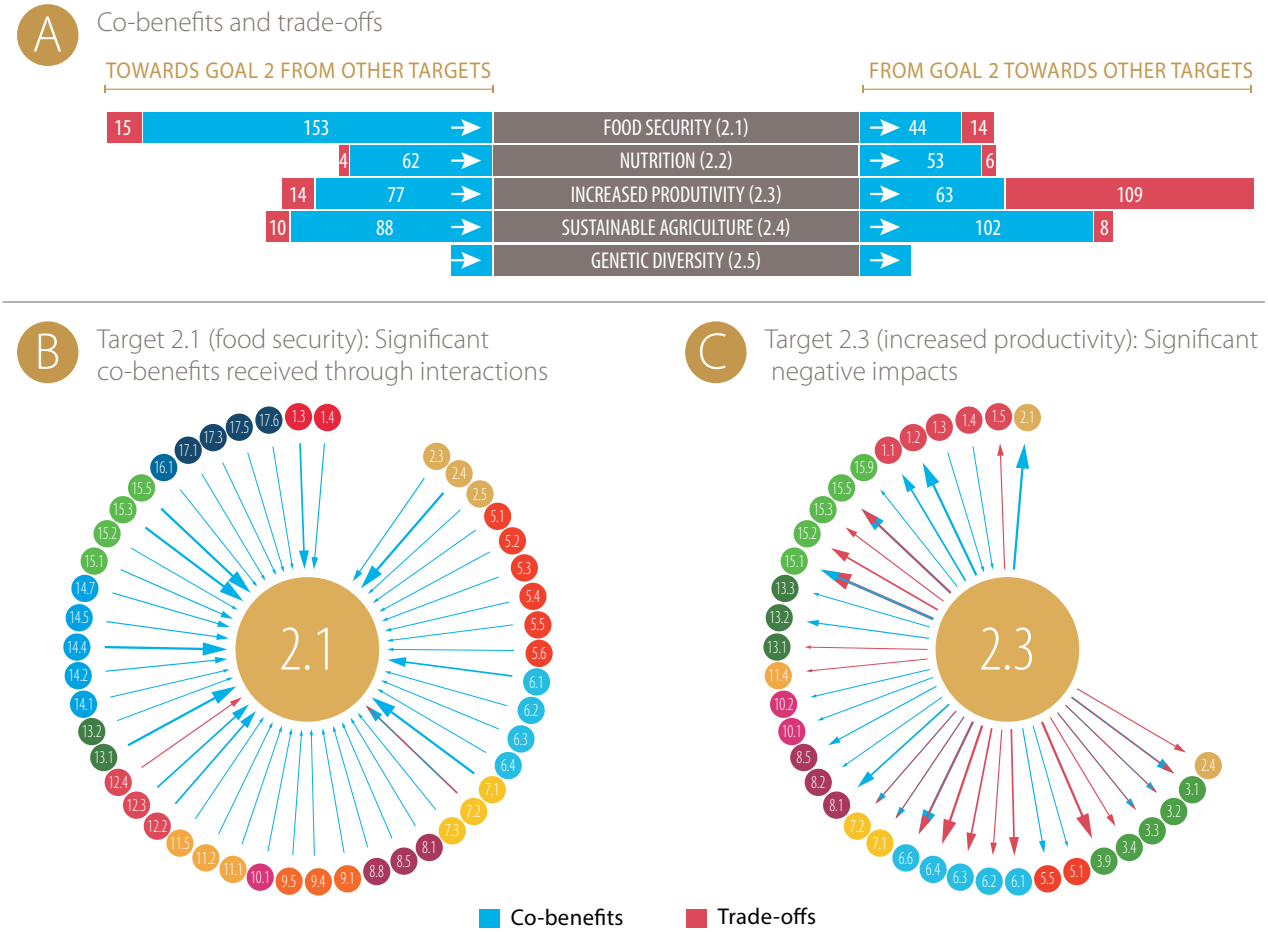
As stated previously, the biggest transformative potentials of the 2030 Agenda do not lie in pursuing single Goals or targets but rather in a systemic approach that manages their myriad interactions. This chapter sets out options for knowledge-based transformations towards sustainable development, using the six entry points introduced in the previous chapter that relate to human well-being; sustainable and just economies; sustainable food systems and nutrition patterns; energy decarbonization and universal access to energy; sustainable urban and peri-urban development; and the global environmental commons.

Although some of those entry-points may seem to single out individual Goals, the Report focuses on the systems in which they are embedded. Progress on any Sustainable Development Goal will depend on a range of interactions with other Goals that either support achievement through co-benefits or hinder achievement through trade-offs. At the same time, any intervention directed towards a particular target will cause chains of influences – intended and unintended – on other targets (see for example, figure 2-1 relating to Goal 2 (Zero hunger)).

Harnessing the transformative potential of those systems as accessed through the identified entry points, implies a careful and structured management of interactions. Progress on all the Goals will only be achieved if important trade-offs are addressed and transformed, and if co-benefits are deliberately realized. In other words, managing the arrows is more important than managing the boxes/circles of individual targets.

The four levers introduced earlier – governance, economy and finance, individual and collective action, and science and technology – are critical to achieve successful transformation. Each lever is a powerful agent of change in its own right and impact the Goals through the identified entry points. It should be pointed out, however, that true transformation is possible only when the levers are deployed together in an integrated and intentional manner. Such an integrated approach will set the world on pathways to transformation. The central innovation needed to advance the implementation of the 2030 Agenda must therefore come from novel combinations of different levers and the novel collaboration of the respective actors in governance, economy and finance, individual and collective action, and science and technology.

Figure 2-1:
Systemic interactions related to Goal 2 (Zero hunger)



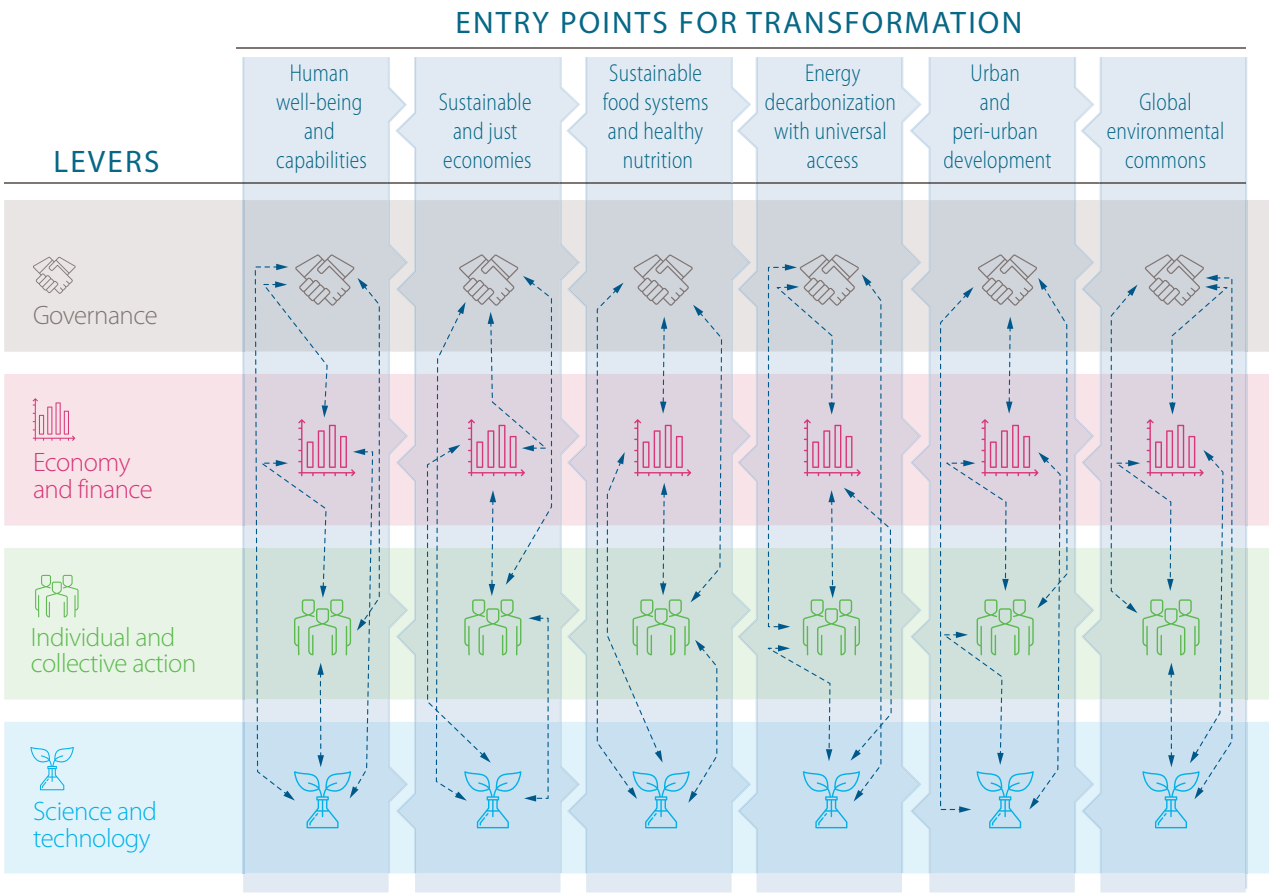
Note: Refer to box 1-2 for methodology.

There is no one-size-fits-all solution for achieving sustainable societal development. Transformations – and relevant lever combinations – will look different depending on the national and regional context, and the time frame or level of urgency of the desired change. In every context, it will be critical to understand the specific challenges, and capitalize on synergies and co-benefits, while minimizing the trade-offs stemming from various interventions.

This report defines a pathway as the integrated and context-specific combination of levers to achieve transformational change towards sustainable development through the six entry points. The levers influence the six entry points (see figure 2-2); the levers have to work together coherently within a particular entry point to drive change, while recognizing that each entry point is connected to other entry points, thereby creating knock-on effects across them.

For example, increasing childhood obesity is a cause for concern in most countries. That is an element of the entry point, *food systems and nutrition patterns*. Depending on the country context, different combinations of levers would constitute pathways towards eradicating childhood obesity. For instance, changes in food habits towards more healthy diets may result from *individual and collective action*, which is informed by *scientific knowledge* that can directly influence choices made by families, while supporting *governance* initiatives such as mandatory food labelling and schools' limiting students' access to sugary drinks. These influences across the levers can go both ways – scientific research supports policy setting (e.g., mandatory food labelling), and policy impact will itself be the subject of further research. At the same time, linkages across entry points matter: urban development that does not incentivize physical activity can make it harder to reduce childhood obesity.

Figure 2-2:
Pathways to transformation



Note: Pathways are integrated and context specific combinations of levers to achieve transformational change towards sustainable development through the six entry points.

2.1. Lever 1 – Governance

Good governance is a Sustainable Development Goal in itself – Goal 16 – that calls for "promoting peaceful and inclusive societies for sustainable development, providing access to justice for all, and building effective, accountable and inclusive institutions at all levels." At the same time, governance is recognized as the means to a broader end; it is an essential lever of the systemic transformations needed to achieve all 17 Sustainable Development Goals.

The 2030 Agenda represents a new mode of governance, one ultimately defined not through legally binding international agreements, but through goals.[120] Governance by goals holds great potential, but success will depend on a number of institutional factors, including how States act on their commitments to the 2030 Agenda and how they strengthen related global governance arrangements and translate global ambitions into their national, subnational and local contexts.[121] Governments will need to prioritize policy coherence, overcome sectoral silos and align existing rules and regulations towards achieving the goals that are interlinked across sectors.[122] New integrated approaches that take into account systemic interactions and causal relationships between goals and policies are needed.[123] Governments will need to be open to transformative learning through experimentation and innovation,[124] a mode of working that may be new for many government entities. Adequate State capacity is among the key factors for successful sustainable development policies.[125]

Effective, transparent, accessible and inclusive institutions will form the cornerstone of governance by goals. Many Member States are demonstrating their commitment to these values: 125 countries have passed laws guaranteeing the individual's right to access public information. However, more needs to be done as the right to appeal violations of those laws to an independent administrative body – viewed as

essential to successful implementation – does not exist in nearly one third of those countries. Effective and transparent institutions can fight against corruption and make policy and budget planning in a transparent and rigorous manner, with citizen participation where possible. Currently, actual public spending in one out of ten countries is not within 15 per cent of their yearly planned budget, and over half of low-income countries deviate by more than 10 per cent from their planned budget. Effective institutions must also protect rule of law and access to justice and guarantee a safe and productive space in which civil society organizations can operate. Recent trends in that regard are troubling, with countries around the world seeing increased numbers of killings of civil rights activists, journalists and trade union leaders. A safe civic space is critical, if governments are to benefit from the full and active participation of its citizens – a key source of creativity and innovation that achieving the Sustainable Development Goals will require.[126]

Governments drive implementation of the Goals in many ways. There is no one-size-fits-all solution, so governance approaches need to be diverse, tailored, innovative and adaptive, using science to support decision-making and develop early-warning systems that can pick up and authenticate weak signals.[127, 128] All governments should incorporate targets and indicators into their national plans and budgets, formulate policies and programmes to achieve them, and create institutions that deal with uncertainties and risks, as well as systems for monitoring and evaluation.

The primary actors in policy design and implementation are governments, and they will be effective only when they work with other key actors, including the private sector and civil society organizations at the regional, multilateral and international levels. Inclusive governance that involves State and non-State actors will be able to support more effective policy interventions by shifting the incentives of those with power, reshaping their preferences in favour of sustainable development, and taking into account the interests of previously excluded participants.[129] Furthermore, an increasingly connected and globalized civil society and private sector can – through individual and collective action – play a supportive role in governing transboundary flows of goods, capital, information and people where individual States may have limited options.

Scientific and research communities can offer evidence-based options for action, taking advantage of the latest technologies and providing an important perspective on the potential and pitfalls of various governance alternatives. To keep up with scientific advances, governments need to invest in knowledge systems – indicators, data, assessments and sharing platforms.[130] Scientists and researchers can provide an invaluable service in measuring genuine progress toward the Sustainable Development Goals and helping governments and other stakeholders to assess which governance arrangements are working, and where course correction is needed.

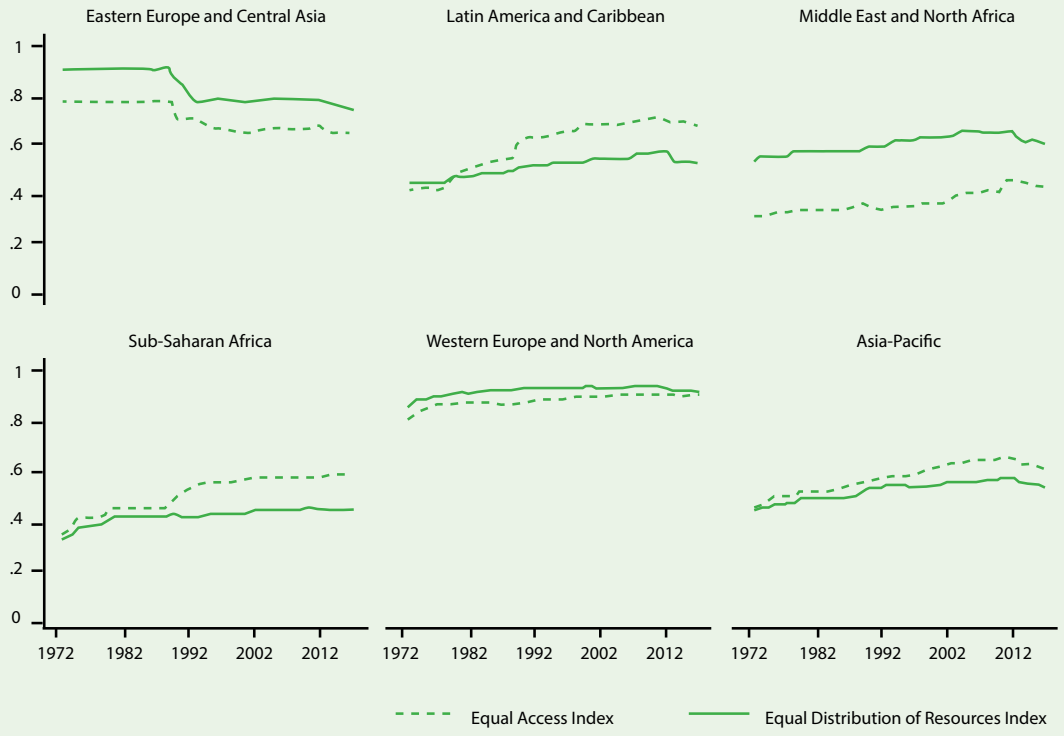
While many of the Goals can be addressed at the local and national levels, other issues transcend national frontiers, such as flooding, pollution or disease outbreak. Traditionally, such issues have been resolved through agreements between States. One successful example is the Montreal Protocol that has helped manage damage to the Earth's ozone layer.[131]

There are opportunities for moving in pragmatic, open and pluralist directions in global governance.[132] The last 10 years have seen the development of a myriad of new governance arrangements, involving a wide range of actors working individually and collectively. The Non-State Actor Zone for Climate Action (NAZCA) records over 17,000 examples of such collaborations including subnational governments, the finance sector and private industry alongside non-governmental and civil society organizations.[133] While voluntary in nature, many such initiatives have significant potential to contribute to global goals, particularly because some also undertake rigorous monitoring and evaluation.[134]

Different actors may have differing views on how sustainable development can best be achieved.[135] However, there are several points of agreement in global sustainable development governance: (1) involving grassroots actors in processes towards inclusive, multi-scale politics;[136] (2) identifying and supporting regimes and transformative alliances between traditional and new actors (governments, academia, science, citizens, cities, private sector) towards greater dynamism in transformative governance;[137] (3) improving the ability to manage hard choices, build coordination and consensus, and channel the necessary resources.

Box 2-1
Political equality[138]

Both socioeconomic and political equality are fundamental for leaving no one behind when implementing the 2030 Agenda. Achieving equality requires a deep structural transformation of social, political and economic relations. Analyses of inequality normally focus on individual outcomes, notably income inequality. Such analyses can be motivated by the idea that income equality – at the level of individuals – is both a cause and consequence of other forms of inequality.[139] Research shows, however, that a diverse set of opportunity structures that go beyond individuals' control affect income inequality between individuals and groups.[140] Thus, in order to achieve the Sustainable Development Goals directly related to reducing inequality, both socioeconomic and political inequality must be addressed.



Data from the Varieties of Democracy (V-Dem) project show how socioeconomic and political equality varies across societies.[141] First, patterns of equality differ across world regions; for instance, in Eastern and Western Europe and the Middle East, levels of equality in the distribution of resources is higher than levels of equality in access to power. The reverse is generally true in Asia, Latin America and Sub-Saharan Africa, where equality in access to power is higher and equality in the distribution of resources is lower[142] (see figure above). Second, only a very small share of the world's population lives in societies with an equal distribution of power by gender, social group and socioeconomic status. Over 5 billion people live in societies where women are discriminated against when it comes to political rights and freedoms.[143] Regarding power distribution by socioeconomic status, States in which the less wealthy are partly excluded from the political process are home to 4.6 billion people.[144] Third, while there is a cluster of countries that have achieved high levels of equality in both distribution of resources and access to power, in many countries, equal distribution of resources does not lead to equal distribution of power, and vice versa.[145]

Exactly how inclusive institutions are to be designed depends on a better understanding of the relationship between socioeconomic and political inequalities.

2.2. Lever 2 – Economy and finance

Economic policy and financial flows are powerful levers for achieving the transformations necessary for the Sustainable Development Goals. At the same time, they can be limited – and even counterproductive – as they set incentives and drive action towards sustainable and socially just outcomes. Strengthening those instruments so as to avoid undesirable outcomes requires a rethinking of their effects beyond purely monetary or financial terms, which will be discussed subsequently as an entry point for transformation to sustainable and just economies. This section introduces the principal components of the economy and finance lever.

Economic policy typically encompasses fiscal, monetary and trade policy, while financial flows include flows from public and private sources, within and across national borders. Policies often signal ends towards which financial flows are directed and can have strong cross-border effects. Historically, trade has been an engine for development and poverty reduction by providing access to new markets and facilitating the sharing of technologies and ingenuity. Trade in sustainable technologies can facilitate greater global adoption and technology transfers, assist in scaling up such technologies, and accelerate broader progress towards sustainable development. Trade policy can be used to forge new partnerships and create shared interests among countries as well as open up employment opportunities and lower the costs of goods. Trade subsidies can be applied or eliminated to support the protection of scarce natural resources and reduce environmental degradation, for example, by limiting overfishing or unsustainable agricultural practices.[146] Policies that encourage trade in sustainably produced goods and services with fair prices, decent labour conditions and wages, and environmentally friendly production techniques can significantly boost progress toward the Sustainable Development Goals.

As with trade in goods and services, the ways in which finance flows within countries and across borders shape the Sustainable Development Goals outcomes. Minimizing the volatility of financial flows is important for ensuring resilience against shocks and providing consistent and predictable public spending for social welfare programmes. Long-term investment decision-making combined with capital account management can help to reduce volatility.[147] Adequate fiscal and foreign reserve buffers are even more important, given the interconnected nature of the global economy.[148] Remittances constitute important cross-national flows in many countries.

Attracting private capital and encouraging official development assistance (ODA) towards sectors and activities that enhance human well-being and reduce environmental externalities is also critical. It is estimated that developing countries face an annual investment gap of $2.5 trillion relating to Sustainable Development Goals implementation.[149] Health and education spending alone will require massive investments, with estimates ranging from additional spending of $1.2 trillion in 2030 in low-income developing countries and emerging market economies[150] to only $200 billion to $300 billion in low-income and lower-middle-income countries,[151] with the differences based on the definitions of additional spending.[152] Massive investment will also be needed in advanced economies.

Closing the financing gap will depend on public finance, complemented by other sources. Fiscal

policy is key in this respect: effective tax policies can not only generate resources for public expenditures and investments within the regions where economic activity takes place, but also support the reduction of inequalities. Predictable and transparent tax rules can also reduce illicit financial flows and increase investment in sustainable goods and services.

Official development assistance remains vital in many developing countries. ODA amounted to $147.2 billion in 2017, remaining flat relative to 2016, and capping a period of steady growth over the last decade. Five countries (Denmark, Luxembourg, Norway, Sweden and the United Kingdom) met or exceeded the target of 0.7 per cent of gross national income. However, on aggregate, donors fell short of that target, reaching an average of 0.31 per cent of GNI. International financial cooperation continues to be significant, even as it is changing in some ways[153] (see box 2-2)

Bilateral and multilateral providers have scaled up blended finance. At least 23 out of the 30 members of OECD Development Assistance Committee engage in blended finance. Blending activities by donor governments mobilized a total of $152.1 billion from commercial sources between 2012 and 2017. The activities of development finance institutions also reflected this trend growth. In 2017, nine development finance institutions reported that they had financed over $8.8 billion in projects through blending. Blending might advance some Sustainable Development Goals more than others, as most blended deals are focused on sectors with significant potential for economic returns.[154]

Climate finance has also seen significant growth, even as it remains below the commitment made by developed countries to jointly mobilize $100 billion a year by 2020. Total climate finance flows from developed to developing countries – including public flows and mobilized private flows – reached $71 billion in 2016, an increase of almost 20 per cent over 2015. Both public and private flows increased in 2016, from $49 billion to $56 billion and from $11 billion to $16 billion, respectively.[155]

Box 2-2

The continuing significance of international financial cooperation

Official development assistance (ODA) remains central to achieving the SDGs in many countries. ODA to least developed countries increased 10.2 per cent in real terms in 2017, but the increase mainly reflected aid for humanitarian assistance in three countries.

The 2030 Agenda has significantly broadened the set of global development priorities, and about one quarter of bilateral ODA is now dedicated to humanitarian expenditure and in-donor refugee spending, compared to less than one sixth in 2010. While social sectors remain the largest ODA category, social spending has fallen as a percentage of total ODA, from 40 per cent in 2010 to 35 per cent in 2017. That reflects a shift in donors' focus to economic aid and support for production sectors. Assistance to economic infrastructure and services – the second largest ODA category – has been growing in recent years, particularly in the energy sector.

As humanitarian expenditure and in-donor refugee spending have risen, the share of ODA for country programmable aid and budget support has decreased in recent years. In 2017, the share of ODA for country programmable aid was 48.3 per cent (6.6 percentage points below the share in 2010), while ODA provided as recipient-country budget support was $3.3 billion (compared to $4 billion in 2010).

South-South cooperation and triangular cooperation are continuing to expand and are making a vital contribution to the implementation of the 2030 Agenda. A 2017 survey conducted by the Department of Economic and Social Affairs of the United Nations found that 74 per cent of developing countries provided some form of development cooperation, compared to only 63 per cent in 2015. However, such cooperation complements ODA rather than replacing it; many countries reported rather modest expenditure on South-South cooperation, with only 16 per cent of countries reporting expenditure of $1 million or more per year. Triangular cooperation has also been increasing in scope across regions: 51 per cent in Latin America, 21 per cent for multiregional projects, 13 per cent for projects in Africa and 11 per cent for projects in Asia-Pacific.[156]

While the primary mandate of central banks is to uphold macroeconomic policy, central banks can also play a role in directing financial sector development, promoting financial inclusion and aligning the financial system with sustainable development.[157]

Development finance institutions, including public development banks at the multilateral, national and regional levels, represented $1.9 trillion in investments in 2018, and can also play a significant role.

Increased national public spending is important, but it will not suffice alone to generate enough funding toward the Sustainable Development Goals. Private investments – including foreign investment – is critical. Even a limited proportion of global finance could ensure the achievement of the Goals. As an indication of the global financial environment, global financial assets are almost $140 trillion. Institutional investors, notably pension funds, manage around $100 trillion, while the bond markets stand at $100 trillion and the equities market at $73 trillion.[158]

Steering foreign direct investment (FDI) and private domestic spending towards the Goals can be achieved through initiatives like social, environmental and corporate governance reporting; sustainable stock exchange systems; or principles for responsible investing.[159] But risks associated with Goal-related investment must also be reduced. Blended finance, as discussed earlier, is one modality through which risks are shared with guarantees and public-private partnerships.[160]

Driven partly by legislation and public pressure, some investors are taking account of sustainability when making investment decisions.[161] Although current market practices do not yet reflect the shift towards sustainable finance at the levels needed, there are some changes in a positive direction. In 2018, for example, 17 per cent of European Union pension funds considered the risks to their portfolios posed by climate change, an increase from 5 per cent a year earlier.[162] In June 2019, the European Commission published new guidelines on corporate climate-related information reporting as part of its Sustainable Finance Action Plan. The guidelines will provide companies with practical recommendations on how to better report the impact that their activities are having on climate, as well as the impact of climate change on their business.[163] Recognizing the threats from climate change, investors themselves are calling for action; recently, investors managing over $34 trillion in assets sent an open letter to the Group of 20 (G20) demanding climate action.[164]

Finance flows also depend on the other levers. Governance can establish priority areas for investment and, in developed countries, set adequate levels of official development assistance, while new technology can help mobilize domestic resources and speed up the flow of remittances.

2.3. Lever 3 – Individual and collective action

Empowerment, self-determination and participation are bedrocks of human well-being. Engaged citizenry with the tools to effect change – especially for groups most at risk of being left behind – are essential forces for advancing sustainable development.[165] Enabling people to participate in setting development priorities, monitoring results and holding decision makers accountable ensures that policies are tailored to the needs of the population, and increases the sustainability of their impact.[166] Encouraging and enabling people to contribute, individually or collectively, expands resources for development and advances human ingenuity for innovation.[167]

Women's empowerment is essential for supporting transformations to sustainable development. Yet, in many instances, women and girls do not receive the same economic, social and political opportunities as men and boys. Women hold only 23.5 per cent of seats in Parliaments; the unemployment rate for women is 1.24 times that of men; and violence against women is a strong limiting factor for empowerment. In least developed countries, 38.1 per cent of women have experienced intimate partner violence.[168]

Advancing women's empowerment through legal reforms, policies, programmes, advocacy and other means would be a game changer for individual and collective action by half the world's population, with profound impacts across a range of Sustainable Development Goals. Empowering women as policymakers can have impacts on the scale and distribution of public goods in ways that better reflect women's preferences. Research showed that increasing the representation of women in policymaking also raised adolescent girls' career aspirations and educational attainment.[169, 170] Women's empowerment can also benefit conflict reduction and prevention: peace agreements with female signatories have been associated with durable peace.[171]

Women and girls are disproportionately affected by climate change and natural disasters. Studies have shown that women and children are 14 times more likely than men to die during a disaster and are more reliant on agricultural work.[172, 173] Given their exposure, women can offer valuable insights and solutions into better managing climate risk.

People's participation is an asset for development but is also valuable in and of itself. People value the ability to influence their own lives and those of their communities, locally and globally. People who are healthy and well informed are in a better position

Box 2-3

Cognitive capacity for sustainable development choices

During the long period of human evolution, humans have overcome multiple complex challenges, and remained highly adaptive. There is therefore reason to hope that we will also overcome the current challenges to sustainability that are faced on a societal – indeed global – scale.

Evolutionary adaptation is most often based on tangible experiences, short-term outcomes and relatively straightforward theories of change. Several aspects of the transformation towards sustainability can be different. Carbon dioxide emissions, for example, are not seen, smelled or directly experienced as harmful, and their negative impacts will occur relatively far into the future, while they are often associated in the present with behaviours that are immediately useful or pleasurable. Their likely impacts and delayed risks are inferred from science-based models rather than immediate individual experience, although that may currently be changing.

Changing behaviours towards evolutionary adaptation in such a context can therefore be different from other contexts in which humanity has had to deal with society-wide challenges. Individuals will play a pivotal role in driving the necessary transformations. Understanding how people – as consumers and engaged citizens – make choices and decisions in that regard can help to further motivate such action.[179]

Cognitive science, psychology, behavioural economics, neurobiology and brain research can provide important insights in that regard.[180] They might indicate, for example, what is going on in our brains when we hear science-based information about sustainability challenges, and consequently make decisions and choices.

Recent research indicates that individual competencies to make such qualitatively different decisions that will accelerate the transition to sustainability vary and are strengthened by the provision of supportive and stimulating environmental conditions in early childhood,[181] formal and informal high-quality education, and lifelong learning. Such interventions do not narrowly target specific choices and actions, but rather contribute towards a more generalized ability. Many of them are expressed as parts of different Goals and targets, but their consolidated impact in empowering people to make choices towards sustainability itself is only now becoming directly evident.[182]

to take advantage of opportunities as they arise and to engage in public dialogue.[174] Empowerment and enhanced capabilities are thus not just the objective of sustainable human development, but also a lever for change (see box 2-3).

Transformative change will mean harnessing bottom-up social, technological and institutional innovation, including indigenous knowledge and creativity at the grassroots level and in the informal sector, particularly – but not exclusively – in developing and emerging economies.[175, 176] For example, coastal and river communities have been living and coping with weather events for centuries; they have accumulated critical knowledge that could be applied to climate change adaptation. Innovations that combine advanced and traditional technologies, bringing together the best of multiple forms of knowledge, also need to be scaled up, where available, so as to have greater reach.[177, 178]

Transformative change also requires the reconfiguration of social practices, social norms, values and laws that promote unsustainable or discriminatory behaviour and choices[183, 184] to, for example, ease the disproportionate burden of care work on women or to provide incentives for consuming fewer disposable goods and recycling. Often behaviour is extremely culturally embedded and linked to power hierarchies and dynamics of influence that strongly condition individual choices as well as collective action.[185] The political and legal marginalization of some groups and the inequalities between men and women must be eliminated in order for all people to be equally able to participate fully in society.

There are many mechanisms for empowering people, changing behaviours and expanding space for collective action. Laws and regulations, taxes and fines are strong signals of the importance society places on certain behaviours. Advertising and public information campaigns can influence individual decision-making

and beliefs about what others are doing and thereby shift norms.[186] Increasing the civic space for people to organize and participate in public dialogue and decision-making increases the likelihood of arriving at representative outcomes. Unions, political parties, women's groups and other collectives have provided the means for forming shared goals and pursuing them jointly (see, for example, box 2-4).[187]

Individuals and households also need access to more information and facts on which to make informed choices for themselves and for society as a whole. Sometimes, simply providing explicit information will be enough, but personal decisions can also be influenced if target behaviour is made easier, more convenient and more attractive[188] or the default option.[189] The insights of behavioural economics show the potential of peer pressure, for example: it has been found that people make more efforts to use less energy if they are informed that they are consuming more energy than their neighbours.[190]

Box 2-4
Adaptive collaborative management

Social norms that have been perpetuated over centuries can be mitigated in certain contexts through adaptive collaborative management.[191] That involves iterative loops of joint problem analysis, planning, action, monitoring, reflection and social learning, followed by appropriately adapted new action, as actors strive to move from an undesired situation to a desired, agreed-upon future state.[192, 193] The transformative potential of adaptive collaborative approaches has been attributed to their strong focus on social learning.[194] Inherent in adaptive collaborative management is the notion of dynamic, complex and uncertain systems.[195]

In Nepal, Zimbabwe and Uganda, for example, adaptive collaborative management has empowered both women and men to participate in natural resource management. In Uganda, adaptive collaborative management has opened to women domains that were traditionally controlled by men, including tree planting – which symbolizes land ownership – and political participation.[196, 197]

2.4. Lever 4 – Science and technology

Science and technology are at the heart of the 2030 Agenda, included as one of the means of implementation under Goal 17. Realizing the full potential of science and technology depends on a host of actors, including scientists and engineers in both the public and private sectors, entrepreneurs, financiers, policymakers and educators, among others.

Science itself establishes the factual basis, anticipates future consequences, generates and assesses evidence, and thus contributes towards finding pathways to sustainability transformations. Chapter 3 will examine the important role of science in sustainable development in greater detail.

Technological innovation has long been recognized as crucial to achieving development objectives. Scaling up applications of existing scientific knowledge and technological innovation – in both the natural and social sciences – while pursuing further research, can enable shifts away from business-as-usual actions and address development challenges across many sectors. Often the technology already exists and the task is to identify and address the obstacles to widespread deployment. United Nations and Member State initiatives, including the Technology Bank for Least Developed Countries and the Technology Facilitation Mechanism could promote the sharing and transfer of technology towards those ends.

In the context of the Sustainable Development Goals, technology can be central to resolving trade-offs that can arise if individual Goals and targets are addressed in isolation. For example, target 2.3 requires a doubling of agricultural productivity, which could be achieved by prioritizing productivity gains over everything else, but that could then negatively impact a myriad of other targets, including those related to livelihoods, health, climate change mitigation, biodiversity and water. However, those issues can be minimized through the strategic deployment of new technologies – from advanced water use sensors to climate-smart agriculture, to renewable energy technologies.[198] In another example, advances in gene-editing technologies, notably Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR),[199] can improve the prospects for gene therapy at the individual level with gains in productivity and control vector-borne diseases such as malaria, and facilitate the precision breeding of plants and animals.[200] Deploying advanced technologies like artificial intelligence could also play a major role in achieving the Sustainable Development Goals. Many such applications are under development but need careful assessment of potential broader consequences before deployment.

Fully leveraging the potential of science and technology will require substantial investment in research and development (R&D).[201] Currently, global investment stands at nearly $1.7 trillion per year, of which 10 countries are responsible for 80 per cent.[202] While some developing countries are accelerating their R&D investment at a faster rate than their developed country counterparts, most developing countries, especially least developed countries, small island developing States and land-locked least developed countries,[203] need better technology and knowledge access through cooperation with developing countries, and through modalities such as South-South and triangular cooperation.

However, developing technology is not enough; technology must be made available, accessible and sufficiently attractive to encourage widespread adoption, accompanied by the development of relevant user capacity.[204, 205, 206, 207] Countries need more locally relevant content, local innovation centres and technology hubs, and support for open data initiatives. The transfer of technology, especially to institutions in developing countries, will be critical to scale up and accelerate the implementation of the 2030 Agenda. The private sector and public-private partnerships can promote innovations aimed at sustainable development, appropriately protecting intellectual property rights while increasing access of developing countries to essential goods and technologies.[208]

Technology also plays a central role in discussions around inequality. On the one hand, inequalities in access to, or capacity to work with, technology threatens to translate into a broader set of inequalities related to well-being. Some of those inequalities are well documented: for instance, there is a gender gap in mobile internet use in developing countries, estimated at 23 per cent globally, with especially high values in South Asia (58 per cent) and sub-Saharan Africa (41 per cent), but down to 2 per cent in Latin America.[209] Such persistent gaps in connectivity can also be observed among other population groups. In order to integrate social objectives in science, technology and innovation policies, it would be important to consider the specific situations and needs of poor people, women and other vulnerable groups.[210] Otherwise, impoverished and vulnerable populations may have to deal with unsuitable technologies chosen by others.[211, 212]

At the same time, new technologies hold the potential for delivering great benefits, for example by enabling new business models and by formalizing traditionally informal activities, and providing access to finance.[213] The use of information and communications technology (ICT) and accessible and assistive technology can improve the quality of life of persons and children with disabilities by increasing access to education, employment, community activities and other services. If considered in line with the Convention on the Rights of Persons with Disabilities and if technology developers prioritize accessibility for all, ICT can be a critical driver to ensure that the Sustainable Development Goals are achieved for persons with disabilities. Nonetheless, here as elsewhere, cultural norms can act as barriers to access and usage.[214, 215, 216, 217, 218, 219, 220, 221, 222, 223]

Artificial intelligence (AI) promises to bring a new generation of sustainable development solutions. However, in order to foster public trust in AI systems, AI regulations and codes of conduct should strike a proper balance between technological progress and people's right to privacy and human dignity.[224] Digitalization is often described as a huge upheaval, to which societies must adapt. On the other hand, digitalization must be shaped in such a way that it can serve as a lever to support transformations towards and be synchronized with sustainability.[225] For example, with job losses due to technological change being anticipated at various scales, policymakers must work in partnership with the private sector to provide effective measures to support displaced workers towards new jobs.[226, 227]

Our entire future – the way we work, move, interact and experience world – will be shaped in countless ways by digitalization. It is critical to ensure that the digital revolution is shaped in a comprehensive and far-sighted manner that prioritizes equity, accessibility, inclusion, human dignity, international collaboration and sustainability. [228,229]

2.5. Entry point 1 – Human well-being and capabilities

Key messages

1. In recent decades, the world has made substantial advances in the areas of human well-being and capabilities, including improvements in life expectancy, education and quality of life, but extreme deprivations linger, and progress remains uneven. National, regional and local authorities and communities should focus on reducing gaps in opportunities and rights between social groups who are most at risk of being left behind in their own territories.

2. Those who have just moved out of extreme poverty and the 4 billion people who do not have any form of social protection remain highly vulnerable to shocks that threaten to push them into extreme poverty. Actions must be taken to eliminate deprivations and build resilience, especially through targeted interventions, where poverty and vulnerability are concentrated or where millions risk being left behind.

3. Growing economic and social inequality limit access to opportunities for the poor and marginalized, which in turn limit chances for upward mobility and subsequently lead to widening gaps in income and wealth. Changes in access to opportunities can reverse trends of growing wealth and income inequality as well as inequalities in opportunities and support upward mobility.

4. Eradicating world poverty and reducing inequality are closely interrelated goals that require expanding interventions and measures to address the multidimensional and overlapping nature of poverty in education, health care, access to safely managed drinking water and energy, access to sanitation services, exposure to infectious diseases and many other critical dimensions of well-being. Economic growth can contribute to absolute income poverty alleviation, but GDP growth will not address multidimensional poverty by itself. Measuring and directly tackling inequalities and deprivations are requirements for advancing well-being.

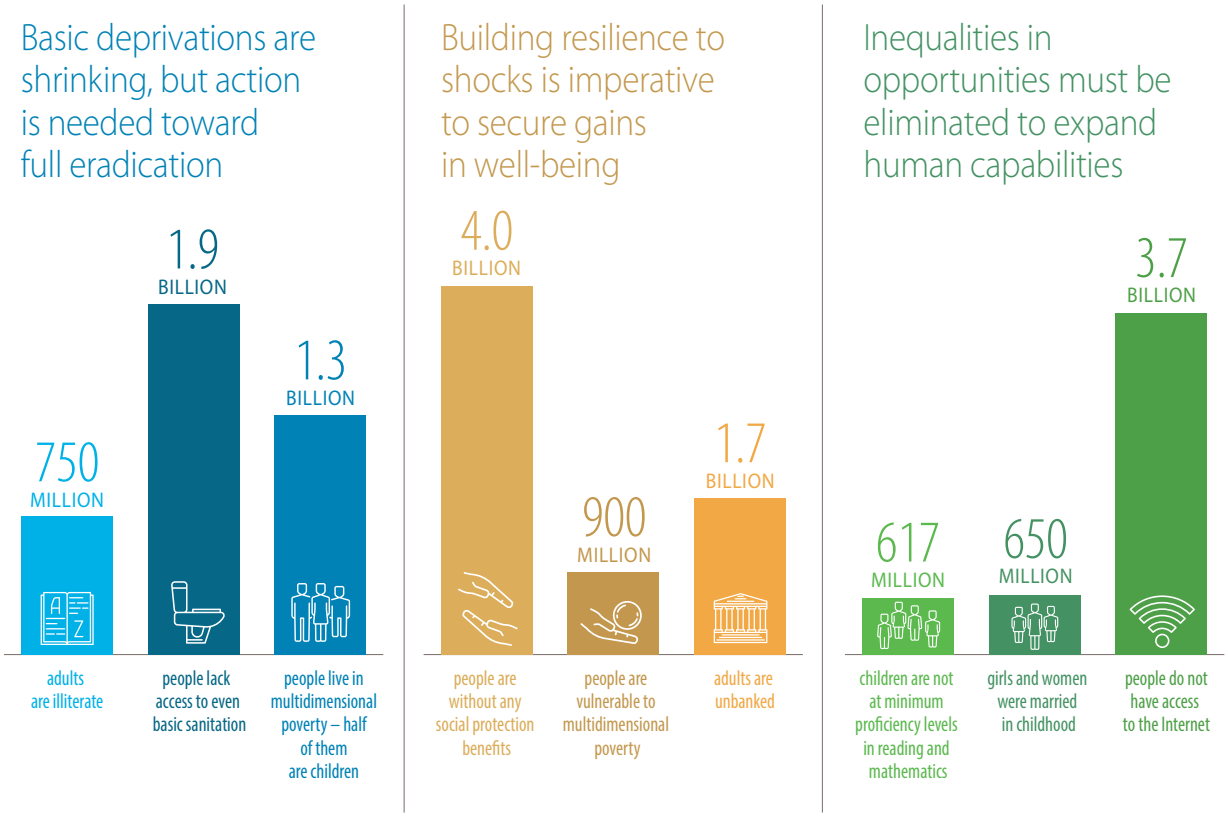
5. People are the greatest asset in the fight for sustainability. Furthering human well-being and protecting the earth's resources require expanding human capabilities so that people are empowered and equipped to bring about change. Investments are also needed in early childhood development, access to high-quality education, greater protection against natural and technological disasters, higher enrolment in science, technology, engineering and mathematics (STEM) programmes, expansion of healthy years of life and attention to mental health and non-communicable diseases.

The 2030 Agenda sets a course "to end poverty and hunger, in all their forms and dimensions, and to ensure that all human beings can fulfil their potential in dignity and equality and in a healthy environment." Advancing human well-being, including material well-being and health, as well as other aspects of life that people value, like education, a voice, access to a clean and safe environment and resilience,[230] is at the core of transformations towards sustainable development. Not only is human well-being inherently important, but people's capabilities in turn drive global social, economic and environmental change according to sets of knowledge, skills, competencies, and psychological and physical abilities. While health and education are often seen as development outcomes, they are also means of achieving key aspects of the global development agenda.[231]

In many respects, progress to enhance human well-being has been made. On average, people today are healthier, more educated and have access to more resources than at any time in history. Nevertheless, there are many extreme deprivations (see figure 2-3). Least developed countries in particular still suffer from high levels of poverty, illiteracy, and under-5 and maternal mortality, while millions of people lack access to safe drinking water and sanitation services. Even those who have moved out of poverty may be vulnerable to shocks, disasters and unexpected health or job changes that could push them back into poverty.

At the same time, many countries are experiencing increasing inequality that limits opportunities for upward mobility.[232] The current conditions not only limit the fulfilment of human rights and dignity for many groups and individuals, they also limit the scope for human action towards many pressing challenges to achieving the 2030 Agenda.

Figure 2-3
Human well-being and capabilities: where the world is falling short



2.5.1. Impediments

Overlapping and concentrated deprivations

Income poverty, poor health, low levels of education, lack of access to water and sanitation, and other deprivations tend to overlap.[233] Households and individuals often suffer multiple forms of poverty. This can be illustrated using the multidimensional poverty index (MPI) which captures the severe deprivations that each person faces with respect to education, health and living standards. In 2015, the number of people living in extreme poverty on less than $1.90 a day had dropped to 736 million.[234] However, the 2018 multidimensional poverty index that covered 105 countries, presents a more sobering picture, indicating that 1.3 billion people live in households with overlapping deprivations.[235] There is also clear evidence that multidimensional poverty has been decreasing more slowly than income poverty.[236]

Those deprivations are concentrated among particular regions and groups. Women, older people, ethnic and racial minorities, certain religious groups, indigenous peoples, persons with disabilities, children and other groups are below the population average in many contexts across measures of well-being. Of the multidimensionally poor, 1.1 billion live in rural areas and almost half are children.[237] Sub-Saharan Africa is home to 342 million of multidimensionally poor people, followed by South Asia with 546 million.[238] Those regions are also home to a majority of extremely poor people and in Sub-Saharan Africa, the number of extremely poor is growing.[239]

Not only are those deprivations overlapping, but they are interdependent and mutually reinforcing. For example, people who lack access to safely managed drinking water, sanitation services, and hygiene services are likely, as a consequence, to suffer health deprivations, especially diarrhoeal diseases, which can cause severe illness and death, particularly in infants and children (see box 2-5). In 2012, lack of access to those services resulted in around 842,000 premature deaths from diarrhoeal disease, over 40 per cent of which were children under 5 years of age.[240]

Box 2-5

Widespread deprivations in safely managed drinking water and sanitation services

Water is fundamental to life and development. Today, more than 2 billion people are drinking contaminated water,[241] and every two minutes, a child dies from a water-related disease.[242, 243] Some 785 million people live without access to any kind of safely managed drinking water service; more than half of those who obtain drinking water from surface water sources live in sub-Saharan Africa, and 80 per cent of those who lack basic services live in rural areas.[244]

In 2017, 673 million people still practised open defecation, and 2 billion people did not have basic sanitation services.[245] The situation is worst in least developed countries, which are home to one third of people who lack basic sanitation services, and only around one quarter of the population have handwashing facilities with soap and water.[246] Those gaps in access increase inequality within and across countries, and women and infants in low-income communities in developing countries are faring worse.[247]

At least half of the world's population cannot obtain essential health services; that means that large numbers of households receive insufficient health care and are pushed into income poverty when they have to pay for health care out of their own pockets.[248] Around 800 million people spend at least 10 per cent of their household budgets on health expenses for themselves or a sick family member.[249] People living in rural areas in particular lack access to a consistent supply of well-trained health workers and teachers due to inadequate incentives for rural placements and/or few incentives for recruitment and retention.[250]

Reducing income poverty can be achieved through equitable economic growth. But addressing multidimensional poverty is more complex, and requires other interventions that need to be carried out simultaneously.[251] Although health and education are often considered as outcomes of successful development in the Sustainable Development Agenda, they are also means to achieving other key elements of the Agenda.[252] Good health, for example, contributes to reducing poverty, attaining quality education and reducing inequalities; likewise, quality education is a precondition for many areas of sustainable development, from reproductive health, mortality and poverty to social equity, social cohesion and environmental sustainability.[253]

Deprivations are passed down across generations

Deprivations experienced by parents often limit opportunities for their children, so that deprivations are typically transferred from one generation to the next. Parents' educational attainment and earnings, for example, are strong predictors of children's educational attainment and future incomes.[254] That is particularly marked in very unequal societies: in the poorest countries, primary school children from the richest 20 per cent of households are four times more likely to learn at desired levels than children from the poorest 20 per cent of households.[255] Among the poorest 20 per cent of the population in low-income countries, only 4 per cent complete secondary school.[256] Income poverty is also closely correlated with poor health outcomes due to a lack of parental knowledge about health, and their inability to afford high-quality health services.[257]

In the United Republic of Tanzania, for example, malaria prevalence is 23 per cent in the poorest households compared to 1 per cent among the wealthiest households.[258] In Nigeria, the wealthiest fifth of women, who, on average, have better access to education and health care, are nearly twice as likely as the poorest fifth to know that HIV can be transmitted to children through breastfeeding.[259] Furthermore, children of less educated mothers or households are more likely to be undernourished[260] and have worse access to safely managed drinking water and sanitation services.[261]

Greater resilience is needed to secure gains in well-being

Poor households are very vulnerable to shocks and setbacks. For example, someone falling ill or dying from an infectious disease can generate significant health, economic and social costs.[262, 263] That can happen to many households simultaneously during times of natural hazards or outbreaks of disease. Climate change, for example, can have long-lasting impacts especially on vulnerable groups who may be less equipped to cope with natural hazards, and who are more exposed to the public health impacts of rising sea levels (see box 2-6).

Poor households are also vulnerable when technological change renders skills outdated and eliminates job opportunities.[264] Faced with the loss of a job or another source of income, families without much savings and without social protection may cut back on food, spend less on health care or forego spending on

children's education. Around 4 billion people worldwide lack social protection benefits.[265]

Attention towards building greater resilience against shocks is also needed at the societal level: for example, taking steps to minimize the spread of infectious diseases due to human mobility and climate change, or to minimize financial volatility that can impact individual incomes and the health of economies. In an increasingly interdependent world, hazards and risks are often woven through communities, societies and economies in complex ways that lead to systemic and cascading risks. The Sendai Framework for Disaster Risk Reduction 2015-2030 emphasizes that building resilience to disasters is a key contribution to sustainable development. Implementation of the Framework can support the Sustainable Development Goals and other landmark United Nations agreements such as the Paris Agreement and the New Urban Agenda – Habitat III.[266]

Box 2-6

Climate change disproportionately affects the most vulnerable

Natural hazards linked to climate change will affect whole communities, but they hit the poor the hardest. The poor are generally more likely to live in floodplains, build their homes with flimsy materials and live without air conditioning that can offer protection during heat waves.[267] They are also more likely to depend on natural resources for their livelihoods.

Poor families are also unlikely to have insurance. In low-income countries, only 1 per cent of households and businesses have catastrophe insurance, compared with 3 per cent in middle-income countries, and 30 per cent in high-income countries.[268] Instead of insurance, most people rely on support from family and governments, which is not always available, especially when disasters affect entire communities. Poor households may resort to selling off assets or reducing consumption to cope with disaster, which leaves them even more vulnerable in the future.[269]

The disproportionate vulnerabilities are felt in tangible ways: from loss of income to poor health. During Hurricane Mitch in Honduras in 1998, poorer households experienced significantly greater loss of assets (31 per cent) than higher income households (11 per cent) despite being less exposed.[270] In Bangladesh, those living in coastal areas are increasingly exposed to health risks due to increasing salinity in freshwater as sea levels rise.[271]

Climate change can also hit hardest at persons with disabilities, who may lack the information or capacity to adapt.[272] Women are also disproportionately affected by climate change impacts: they often lack land rights and access to financial resources, training and technology,[273] and they may have little influence on political decision-making. Similarly, many indigenous peoples do not possess the financial resources or technological capacity required for climate change adaptation.[274] However, women, indigenous peoples and other vulnerable communities can be powerful agents of change when included in the design of solutions, since they are first-hand witnesses of climate change impacts.

Social, economic and political barriers

The deprivations that people experience are not only due to lack of technical or financial resources, but are often linked to deeply rooted structures of social and political inequality and discriminatory laws and social norms. Thus, women typically have fewer opportunities than men; the poor have fewer opportunities than the rich; migrants have fewer opportunities than citizens; and some ethnicities have fewer opportunities than others.[275] The consequences are exclusion and marginalization. The most deprived often experience intersecting deprivations – poor, older or younger age, ethnic group, gender.

In some countries, women are constrained by traditions of child marriage and laws that limit their property rights, for example, or they require approval from their husbands to work. Typically, women also shoulder the bulk of unpaid care work which restricts their access to education and health care services and to paid work.

Persons with disabilities face multiple deprivations that can exclude them from economic, political, social, civil and cultural life, including employment, education and health care. An estimated 80 per cent of persons with disabilities live in poverty.[276]

Refugees and migrants also face numerous barriers (see box 2-7). Action is required to address the root causes of conflict and fragility that generate refugee flows and internally displaced people. Action is also required to facilitate safe and orderly migration.

Box 2-7

Ensuring refugees and migrants are counted and visible

The world will not meet the Sustainable Development Goals if we do not reach people caught in fragile and conflict-affected States, where millions are being displaced and left behind, particularly women and girls. Up to four out of five fragile and conflict-affected States are off-track to achieve select sustainable development targets by 2030.[277] Those States will be home to around 85 per cent of those remaining in extreme poverty – some 342 million people – in 2030. Those countries are also the ones where refugees reside, often for protracted periods; 12 out of the top 15 refugee-hosting countries are considered fragile.[278] People caught in crisis situations, including refugees, are being left out and left behind in progress towards the Sustainable Development Goals.

In 2018, only 15 out of 46 countries that submitted voluntary national reviews – including several which have hosted refugees for decades – mentioned the needs and contributions of the refugee populations. And among those, data were inconsistently reported. Furthermore, those groups are routinely left out entirely of national data collection. Household surveys – with rare exceptions – typically omit people living outside of traditional household settings, including those in refugee camps. Refugees living outside of camps, accounting for 75 per cent of the total number of refugees, are also likely to be rendered invisible as they are not routinely counted in national censuses and are invisible in development plans. Without accelerated action on behalf of fragile States and conflict-affected populations, and inclusion of people caught in crises in national development plans and progress reports on the Sustainable Development Goals, we simply will not meet the Goals. There is a need to take action and correct the course.

Refugees are not the only group at risk of being left behind. Migrants who migrate in order to access higher wage jobs and overcome barriers to socioeconomic mobility are also vulnerable to myriad risks and structural obstacles and forms of discrimination. Moving to a new country often triples the wages of migrants and enables them to escape poverty and send remittances to support relatives at home.[279] Yet, since migrants are invisible to many institutions, they are at risk of being bypassed by commitments to ensure rights, security and a voice. Additional and more widespread national and global efforts to reduce recruitment and remittance costs; recognize the skills that migrants bring; enhance the portability of social security coverage; and remove restrictions on access to paid work for displaced persons warrant greater consideration. The recent adoption of the Global Compact for Safe, Orderly and Regular Migration is a significant step in that direction.

Capabilities for transformation

For sustainable development, the greatest asset is people. They need to be empowered and engaged in community life to enjoy a high level of satisfaction with life and to age in dignity and good health. If they are to cope with emerging technologies, they need the necessary capacities.[280] That means raising the bar in terms of learning opportunities, health care, and resources for innovation. It is not acceptable that 617 million children and adolescents around the world have not achieved minimum levels of proficiency in reading and mathematics. It is even more concerning when we consider that two thirds of these children are in school and not learning.[281] Access to quality education in early childhood, as well as primary, secondary and higher education, are essential to build capabilities for all, including for policymakers and scientists to address the challenges embodied in the 2030 Agenda.

Likewise, the world could do much better to improve health outcomes. In 2016, global life expectancy at birth was 72 years, but healthy life expectancy at birth was only 63 years.[282] People can also lack adequate support for mental health even in richer countries. For example, one study in 2017 found that in high-income countries the proportion of people with depressive disorders being adequately treated was only around 1 in 5, and in low- and middle-income countries it was only 1 in 27.[283] Everyone should be able to enjoy the highest standards of physical and mental health.

2.5.2 Levers for transformation

Achieving all the Sustainable Development Goals requires more forceful action and transformation in the ways that societies foster human well-being and build human capabilities. That is especially true for Goal 1 (eliminating poverty); Goal 3 (good health and well-being); Goal 4 (quality education); Goal 5 (gender equality); Goal 6 (clean water and sanitation); and Goal 10 (reducing inequalities). Guided by evidence, governments, the private sector, civil society, individuals and scientists can initiate new forms of cooperation. They can break cycles of intergenerational poverty and deprivation by creating new incentives and perceptions around the value of investing in human well-being and capabilities – so as to increase quality education, health care, nutrition, clean water, energy, sanitation and technologies – as critical elements of sustainability and resilience.

Governance

Expanding human capabilities and overcoming deprivations and inequalities relies not only on governments, but also on the contributions of many other stakeholders who need to make policies work in practice.

Provide universal access – Eliminating poverty, closing opportunity gaps and building capabilities requires universal health care and education, in addition to services like clean water, sanitation, energy, telecommunications and others. Target 3.8 aims to ensure universal access to essential quality health services, but those services need to be supported by programmes that ensure access and use by those most in need. Otherwise, additional expenditures on health care or other services can disproportionately benefit wealthier groups.[284] Moreover, out-of-pocket payments and user fees at the point of health-care delivery (accounting for approximately 30 to more than 70 per cent of total health-care expenditures in many developing countries) are the most regressive mode of financing health-care systems and often create insurmountable barriers for the poor.[285]

Uganda and other countries have, for example, removed user fees to access public health-care facilities, and have been offering free access to HIV, tuberculosis and malaria treatment. That can significantly increase service use among the poorest populations.[286] That will mean reducing formal out-of-pocket expenditures, as well as building pre-payment insurance mechanisms for access to quality health care.[287] Equality of access can in turn help to reduce poverty (see box 2-8).

In a similar vein, all girls and boys should have access to quality education from pre-primary education to primary and secondary education, as well as technical, vocational and tertiary education, including university. School fees, as well as textbooks, supplies or uniforms, can be limiting factors, especially for the poor.

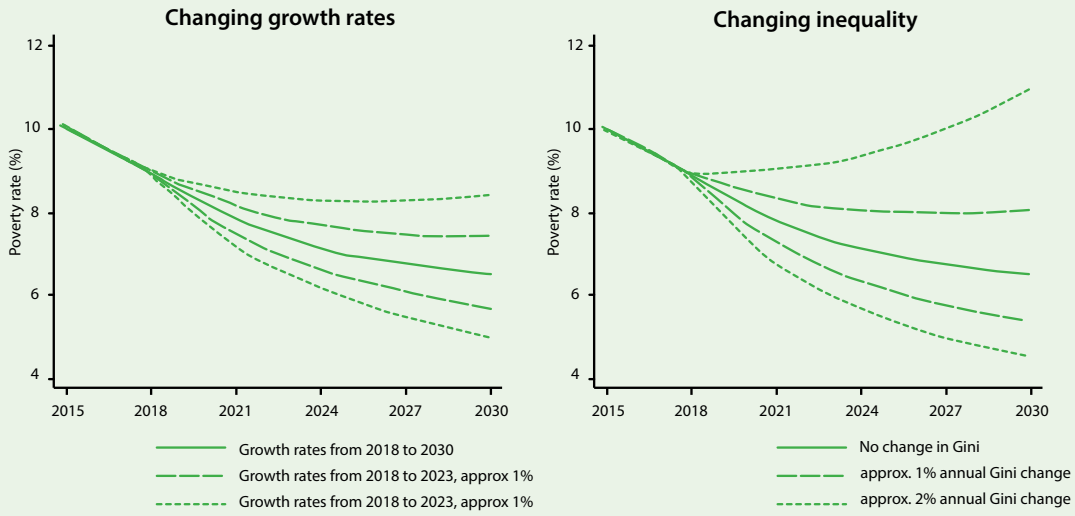
Ensure high-quality services –Governments should provide various forms of incentives to increase the number of service providers and improve their qualifications, extend the hours that services are available and enhance their performance.[288] Countries have been trying to bolster retention rates of staff by offering financial and in-kind incentives, though there is not much empirical evidence on the results, and where available this is mixed.[289] Countries also need to ensure that training in new technologies and techniques is available and encouraged. Education systems, for example, need to address the needs for lifelong learning and advanced skills, while health systems in developing countries need the skills to tackle non-co`mmunicable diseases. Health and education provision also needs to evolve to meet new demands.

Box 2-8

Tackling inequality is good for poverty reduction[290]

The goals of ending extreme poverty – defined by the monetary threshold of living with less than $1.90 per person/day – by 2030 and working towards a more equal distribution of incomes are prominent in international development and agreed upon in the Sustainable Development Goals 1 and 10. The idea that increased in-country inequality is the price to pay for alleviating poverty is clearly misleading. On the contrary, research strongly suggests that reducing inequality might have strong links to reducing poverty. One study uses data from 164 countries that comprise 97 per cent of the world's population to simulate a set of scenarios for global poverty from 2018 to 2030 under different assumptions about growth and inequality. That allows for quantifying the interdependence of the poverty and inequality goals. When holding within-country inequality constant and letting GDP per capita grow according to IMF expectations, simulations suggest that the number of extreme poor (living below $1.90/day) will remain above 550 million in 2030, resulting in a global extreme poverty rate of 6.5 per cent. If the Gini coefficient in each country decreases by 1 per cent per year, the global poverty rate could decrease to around 5.4 per cent in 2030, equivalent to 100 million fewer people living in extreme poverty.[291] Reducing each country's Gini coefficient by 1 per cent per year has a larger impact on global poverty than increasing each country's annual growth one percentage point above expectations. Achieving higher growth rates by one percentage point is often more difficult than decreasing the Gini 1 per cent through government intervention, suggesting that decreasing inequality might be the most viable path to lowering extreme poverty.

Simulations of global poverty under different growth and Gini scenarios



Note: Projected global poverty rate measured at $1.90/day based on 2011 purchasing power parity and assuming that countries undershoot/overshoot the growth projections of the World Economic Outlook by 1 or 2 percentage points annually (left panel) or assuming that countries follow the World Economic Outlook projections exactly, but reduce/increase their Gini coefficient by 1 or 2 per cent annually (right panel).

Eliminate discrimination in laws and norms – Countries need to strengthen the rule of law, enforcing anti-discrimination laws and ensuring universal and effective access to justice. Where there are high levels of inequality among groups, including between men and women, governments and societies can apply legal instruments and incentives, including affirmative action laws and quotas, non-discrimination laws in hiring practices and wages, targeted skills training, campaigns that seek to reduce stigmatization of certain groups, subsidized services, financial inclusion and access to identification to name just a few.[292] In any context, measures need to be

carefully selected to reach the social groups most at risk of falling further behind. For example, Latin American countries might focus on measures that reduce gaps in education attainment and access to justice between indigenous women and the rest of society.

Expand social protection to increase resilience – Social protection should extend beyond workers in formal, full-time jobs. Billions of other citizens in the informal sector or who are unable to participate in the labour market need support so that they are able to withstand hardship.[293] Those efforts can be based on new social contracts between states and citizens embodying the principle that individuals, civil society, the private sector and governments carry joint responsibilities for social well-being[294] and for promoting progressive financing – with contributions increasing with income levels – for various schemes of social insurance.[295]

Economy and finance

Eradicating deprivations, building capabilities and opening up opportunities require investment. Governments can increase public spending, but that is not enough, so the private sector also has to help increase access and offer new approaches to provisioning.

Incentivize private sector investments in capabilities – Much of the decision-making power is in the private sector, so businesses and industries have to share responsibility for human well-being. Performance evaluations for managers and companies at all levels should explicitly include their contribution to social well-being, improving communities and building capabilities of employees.[296] That should also be reflected in the assessments by credit rating agencies. Agreements for foreign direct investment should include contributions to social well-being.[297]

Increase public-private partnerships, ensuring that citizen needs are kept at the forefront – Public funds, even supported by ODA (official development assistance), will fall far short of what is necessary to meet the Sustainable Development Goals. Much more is needed from the private sector, including public-private partnerships.[298] All public-private partnerships should be designed to ensure that risk is allocated fairly and that the public interest is not subsumed into private or corporate interests.

Coordinate systems for funding – Many funding estimates are ad hoc and vary from source to source. It would be better to complement the United Nations information systems for tracking progress with a coherent and coordinated system for estimating funding needs for the Sustainable Development Goals.[299]

Encourage private sector investments in public goods – If it is to invest more in human well-being, the private sector will require greater incentives. Those can come in the form of government regulations and taxation that direct profits towards the necessary public goods.[300] However, it should also be noted that prioritizing human well-being could generate enormous business opportunities for welfare investments. An example of business initiatives that have already made a difference is summarized in box 2-9.

Box 2-9
Private-sector innovations towards better health[301]

The company ViiV Healthcare was granted approval in the European Union in 2014 for its innovative antiretroviral treatment. The approach is based on an integrase inhibitor used in combination with other antiretroviral medicinal products to treat adults and adolescents living with HIV. It has secured approval in the United States and Europe for a new single-pill treatment.[302]

ViiV Healthcare ensures access to its medicines with royalty-free, voluntary licenses offered in all low-income, least-developed and sub-Saharan African countries. In middle-income countries a flexible pricing policy is applied based on GDP and the degree of impact of the epidemic on the country. Based on 14 royalty-free licence agreements, companies manufacturing generic medicines are able to market low-cost versions of all ViiV Healthcare's antiretrovirals for use in donor agency and public-sector programs.

Increase access to finance – Without bank accounts or other access to finance, families are vulnerable to unexpected health or education expenses. Financial inclusion can be facilitated by modern technologies. Mobile phone systems of banking and money transfers like M-Pesa in Kenya and bKash in Bangladesh are reaching the unbanked.[303]

Individual and collective action

Human well-being opportunities and outcomes are shaped by the decisions of individuals, the incentives that drive individual behaviour and the opportunities and drivers of collective action. Behaviours can lead to unintended outcomes from various technological, fiscal and policy actions, so they must be accounted for in policymaking.

Translate evidence into options – Individuals make decisions for many reasons and considering multiple sources of information. They are more likely to base their actions on firm evidence if it is communicated in a clear, interesting and easily understood way that stimulates action (see box 2-10). Social media can support change towards healthier lifestyles, for example, by bringing people together who regularly and publicly report about methods they have used, for example, with stopping smoking, using alcohol or drugs or tackling obesity.

Address barriers to technology use – Safe, convenient, and affordable alternatives to traditional methods for accessing water or energy must also be culturally appropriate and address users' needs. Evidence from Bangladesh, for example, shows that many users are reluctant to switch to newer technologies.[304] It is important therefore to research and fund a variety of solutions that address locally specific needs.

Box 2-10
Shifting behaviour for better health in Indonesia

In Indonesia in 2007, the Government partnered with the World Bank to reduce the prevalence of open defecation in East Java. This was based on "community-led total sanitation", which directly addresses individuals' opportunities, abilities and motivation to change their behaviour.[305] The project conducted market research on barriers to the use of latrines and worked with the local newspaper to hold leaders accountable on sanitation access. The project also tried to motivate people to use sanitation, employing facilitators to illustrate to community groups how faeces from open defecation can contaminate drinking water and spread diseases.[306]

Those activities steadily reduced an established, but harmful practice. Residents of communities selected to receive information about community-led total sanitation were 9 per cent less likely to defecate in the open, and 23 per cent were more likely to build a toilet. The behaviour changes resulted in a 30 per cent reduction in the prevalence of diarrhoea among people in the target communities.[307] In other countries, community-led total sanitation interventions have also been shown to reduce stunting.[308]

Empower everyone for collective action – Policies are the result of debates, dialogue and sometimes struggles and conflicts between different groups of actors. In unequal societies the most influential voices are often those of the rich and powerful. For public dialogue to result in actions that address the needs everyone, all voices need to be heard. That can be achieved through political parties, unions, women's groups and other collectives, all of which need the freedom to organize and gain access to information and knowledge.[309]

Science and technology

Science and technology offer many tools for improving the understanding of risks and possibilities and for guiding different lines of action. New technologies and research in the natural and social sciences are expanding the scope of health care and cognitive development. They are also reducing the costs of health care, education and other services in some contexts and helping to more effectively reach persons with disabilities and those in rural areas, as well as other groups at risk of being left behind.[310]

Apply new technologies to service delivery – Innovative technological solutions are being developed to support universal access to health care and health-care facilities. Those include risk pooling to extend health insurance coverage, tele-health to reach underserved populations and those with limited mobility and activity services to tackle and prevent non-communicable diseases.[311] In addition, in Rwanda, Tanzania and elsewhere, drone technologies are being used to transport lifesaving blood and medicines to remote areas. Similarly, more education for remote areas can now be carried out online. And technology can also increase the frequency and reach of teacher training and certification. Furthermore, technology through online labour

platforms provides new earning possibilities for people in developing countries, provided they have the right skills and adequate connectivity.[312] New technology also offers water recycling and purification using smaller and more portable equipment accessible to a range of users, including those in rural areas.[313] Additionally, those new technologies can transform production processes, which ensures quicker and cheaper service delivery that is also accessible in developing countries. For instance, 3D printing allows for cheap development and low-volume production of complex components.[314]

Generate better data – Policies to expand capabilities should be based on detailed and disaggregated longitudinal data that track individuals through the life cycle and across generations.[315] That means improving data collection and data literacy among decision makers so that they understand life cycle and intergeneration links in deprivations and are better able to align actions with needs and design policies according to specific regional and national contexts. That may include the use of big data and analytics.

Advance medical research and applications – Public health and the management of epidemics and infectious disease can take advantage of the latest technologies. Research organizations can collaborate across the health-care sector to develop innovative, low-cost preventive and curative treatments. Those can tackle communicable and non-communicable diseases, considering especially their variants in low- and middle-income countries, and for women whose different symptoms and needs in dosage are often excluded from medical research. They can also involve treatment for multi-drug-resistant tuberculosis or strategies to address growing anti-microbial resistance.[316] Efforts can develop low-price, high-volume models to expand access to vaccines, diagnostic tests, pharmaceuticals, supplements and family planning in low- and middle-income countries.[317] Finally, new forms of data collection can help reduce the spread of infectious disease (see box 2-11).

Box 2-11
Mitigating health emergencies using emerging technology[318]

Telefonica Research in Spain, in collaboration with the Institute for Scientific Interchange and United Nations Global Pulse, is currently being used in Colombia to monitor the epidemic spread of the Zika virus at the local level. That involves harnessing mobile phone data based on call detail records created by telecom operators for billing purposes, including data on phone calls, text messages and data connections. Those digital traces are collected continuously and provide an ongoing and relatively low-cost way of tracking and identifying human movements at an unprecedented scale. That can help public health authorities in planning timely interventions. In Mexico, Telefonica partnered with the Government to tackle the spreading of H1N1 influenza by monitoring the mobility patterns of citizens' cell phones.[319]

Increase access to technology and information – Access to many services, including health and education, increasingly requires access to mobile phones and the Internet. By 2017, across the world there were 7.8 billion mobile phone subscriptions and 3.9 billion Internet users.[320] And further growth is expected. Even in sub-Saharan Africa, between 2017 and 2025, the number of unique mobile subscriptions is expected to rise from 444 million to 634 million.[321] Nevertheless, that means that close to half of the world's people (48.8 per cent) do not use the Internet, with the unconnected more likely to be women than men and living in rural rather than urban areas.[322] Increasing access means improving technology infrastructure, starting with electricity services and more training in the use of mobile technologies.

2.5.3 Integrated pathways to transformation

Pathways to advance human well-being ultimately require cooperation, collaboration and dialogue between multiple actors and employing many levers of change. There is no single pathway, and different combinations of efforts are required across regions and for countries in special situations.

Just as issues of sustainable development do not operate in silos, the levers of governance, economies, behaviour and technologies are intrinsically linked and changes in one area trigger changes in the others, links that need to be mapped and understood to inform actions for well-being.

A multidimensional approach – Countries should measure and address poverty in a multidimensional

way, with special attention to those dimensions that are the most pertinent in their context and according to their own definitions.[323] Multiple stakeholders usually led by the government, should agree to an understanding of multidimensional poverty that typically includes deprivations in education, health, food/nutrition, housing and social security, and other dimensions that seem important for each country, according to their internal agreements. On that basis they can rethink the country's development process to address multiple Sustainable Development Goals and increase communication and coordination among various actors and between ministries (see box 2-12).

Empowering women in STEM – Enhancing opportunities for women and girls in education can have huge impacts on human well-being and across all the Sustainable Development Goals – including through STEM (science, technology, engineering and mathematics) programmes. The proportion of women in tertiary education has been growing; indeed, it is 4.4 percentage points higher than for males.[324] But for STEM programmes women are lagging behind and make up only 35 per cent of students.[325] Increasing the number of women in science could provide greater job security and well-paid jobs. The starting point should be to address behaviour so that girls feel encouraged and welcomed in STEM programmes. That can partly be addressed through improving media representations of women.[326] Families also have a great influence with mothers' roles and views in particular shaping outcomes for daughters and the perceptions of sons.[327] Teaching institutions and learning technologies, as well as teachers, must have equal expectations of girls and use gender-balanced curricula that take into account girls' interests and provide hands-on learning opportunities. Enrolment can also be balanced through scholarship funds with public and private contributions.[328] The private sector also needs to recognize the business case for expanding the number of women in the STEM labour force.[329]

Box 2-12
Measuring multidimensional poverty at the national level

Multidimensional poverty measurements identify the prevalent vulnerability dimensions among the population and measure them accordingly. Those who are deprived in those dimensions, meaning that they don't have access to the rights, services or goods they refer to, can be characterized at a national level as being left behind. Countries can then coordinate social development efforts between dimensions and sectors to leave no one behind under one coherent logic: a multidimensional poverty measure.

The selected dimensions vary between countries and may be selected based on the country's constitutional priorities, by identifying the basic conditions needed to guarantee better life outcomes. Countries such as Bhutan, Chile, Colombia, Costa Rica, El Salvador, Mexico, Panama and others have all designed their own multidimensional poverty methodology from their specific country needs and priorities. For many of them, the support of the Oxford Poverty and Human Development Initiative (OPHI) has been very important. This has generated data that can be disaggregated by vulnerable sub-groups and provided indicators that can be monitored through time to track progress and help shape public policy.

In 2009, Mexico became the first country to officially implement a multidimensional poverty measurement.[330] El Consejo Nacional de Evaluación de la Política de Desarrollo Social (CONEVAL) developed a measure composed of six equally weighted social dimensions – education and health services, social security, quality and space in the dwelling, basic services in the dwelling and food insecurity. There were also two income thresholds: an income poverty line, and an extreme income poverty line. The social dimensions established in this indicator are part of the 2030 Agenda. Mexico is also simultaneously addressing Goals 1, 2, 3, 4, 6, 7, 10 and 11.

Based on CONEVAL data, federal, state and municipal governments work together to decrease social deprivations. Through working groups, government ministries coordinate and focus on poverty relief programmes with specific targets for each poverty dimension. Between 2014 and 2016, multidimensional extreme poverty fell from 10 to 8 per cent.[331]

Consistent attention to early childhood – Early-childhood poverty, and even exposure to poverty before birth, negatively affects adult attainment, behaviour and health during the whole life cycle of the concerned individuals.[332,333] The most cost-effective way to simultaneously address nutrition, health and

education Sustainable Development Goals is to target pregnant women and young children, especially those in single-parent households and orphans.[334] That should include maternal mental health and support for breastfeeding and encouraging psychosocial stimulation.[335] Businesses can also contribute by providing on-site child-care facilities, as well as paid maternity and paternity leave. Then it is important to ensure universal early childhood education, removing the hidden costs of attending school while improving school facilities for safely managed drinking water and sanitation services[336] (see box). Additionally, providing meals in schools can improve attendance among the poorest families and alleviate hunger and malnutrition.[337]

Box 2-13
Early childhood interventions build capabilities

Adequate nutrition and social nurturing in early childhood heavily influence crucial outcomes in adulthood such as earnings, societal participation, and health. A study of 129 growth-stunted children in Jamaica found that early stimulation interventions of play sessions designed to develop the child's cognitive, language, and psychosocial skills had positive impacts on educational attainment, and reduced participation in violent crimes.[338] Moreover, 20 years later the earnings of the group that received the intervention were 25 per cent higher than the control group and had even caught up with the earnings of the non-stunted comparison group.[339] Early childhood interventions for disadvantaged children can thus improve labour market outcomes and compensate for developmental delays.

Other studies have taken a larger-scale comparative approach to identify higher-impact early childhood interventions. An analysis of the long-term benefits of early education in 12 developing countries found that children who attended preschool stayed an average of one year longer in school and were more likely to be employed in higher-skilled jobs on average.[340] Evidence from 40 developing countries found that early childhood development focusing on parental support, early stimulation and education, nutrition and health, income supplementation, and comprehensive and integrated programmes had positive effects on a child's cognitive development, with the largest effects associated with comprehensive programmes.[341]

Another survey found that in a large majority of affected countries, malaria control programmes of the Global Fund to Fight AIDS, Tuberculosis and Malaria led to substantial increases in years of schooling and grade level as well as reduction in schooling delay.[342]

Building resilience through education and empowerment – Education reduces vulnerability to environmental change.[343] Households with a higher level of education have higher disaster preparedness, are more able to employ non-deteriorating strategies to cope with natural hazards, suffer lower loss and damage and recover faster from catastrophic shocks.[344] More educated households are also more likely to have modern, electrification and other cleaner energy sources, so women and children are less exposed to indoor air pollution.[345] In the digital age, resilience also requires continuous learning in response to technological change. Some projections to 2020 predict a shortage of workers with tertiary education of 40 million and a surplus of medium and low-skilled workers of 90 to 95 million.[346] The mismatch makes education and training critical for future resilience not just for youth, but also for people of all ages who require access to lifelong training and education to remain adept at negotiating changes in technology. In particular, students need education in mathematics and natural sciences, learning to write and communicate persuasively, cooperate in teams and acquire leadership and systems thinking.[347] The 2030 Agenda, emphasizes eco-literacy – understanding the processes that maintain healthy functioning of the Earth system and sustain life.[348]

Creating new partnerships and using technology – Implementing new policies and technologies requires community and private sector engagement.[349] Governments thus need to work systematically with stakeholders to promote acceptance and ownership while improving sustainability and quality. In underserved communities, in particular, it is important to have strong partnerships that leverage the unique skills and resources of governments, the private sector and civil society. That has been the case with health care where resource, infrastructure and technology constraints can make universal provisioning seem unattainable. The developments in Ghana outlined in box 2-14 illustrate the value of innovative practices and cross-sector collaborations for achieving universal health care.

Box 2-14
Partnerships for access to health care in Ghana

In 2003, Ghana became the first country in sub-Saharan Africa to introduce a national health insurance scheme by law, with the goal of providing access to free basic health care services.[350] Between 2004 and 2013, the number of active members in the scheme increased from 2.5 million to over 10 million, covering about 38 per cent of the population.[351] Enrolment in the scheme has increased utilization of maternal health-care services,[352] increased access to medication, clinics, and formal health care,[353] and helped drive improvements in life expectancy, which between 1995 and 2014 rose from 61 to 65 years. Challenges remain however; there are substantial inequities in access to health care that affect poor and rural populations,[354] and the fiscal pressures associated with an increasing set of benefits and an expanding population under cover threatens the sustainability of the scheme.[355]

Like many other countries in Africa, Ghana faces a shortage of health-care personnel, especially in rural hospitals. To address those challenges, Ghana has increased the number of medical training institutions and revised curricula to reflect current trends in health care. In the early 2000s, for example, a strategy was adopted to increase the number of midwives trained and deployed in health service. As a result, over 1,000 midwives are inducted into the profession every year, with a majority employed by the public sector.[356] The Ghana College of Physicians and Surgeons was also established to provide in-country postgraduate training. As part of Ghana's new strategic plan, training institutions are encouraged to increase the intake of all health workers.[357]

Ghana's government has also collaborated with the private sector to expand access to quality health care including through the application of technologies to serve remote areas. For example, Zipline International, a drone-delivery company, plans to expand its operations to transport key medical supplies to 2,000 health facilities across the country. In Ghana, where 30 million people are scattered across wide areas, drones can bypass mountains, rivers, and washed out roads to deliver supplies to the most remote communities at a speed of about 100 kilometres an hour. Those improvements are expected to benefit 12 million people and may help contribute to the Government's efforts to enhance equity and health impact.

2.6 Entry point 2 – Sustainable and just economies

Key messages

1. Economic growth has increased national incomes significantly, albeit unevenly, across countries. That has contributed to advances in human well-being, but the effects on human society and the global environmental commons are unsustainable.

2. In recent times, economic growth, has been deeply unequal, increasing disparities in wealth and income and generating expectations that they will continue to be exacerbated into the future.

3. Current modes of production and consumption may be unsustainable if trade-offs related to human well-being, equality and environmental protection are not addressed, representing a challenge to the achievement of the entire 2030 Agenda.

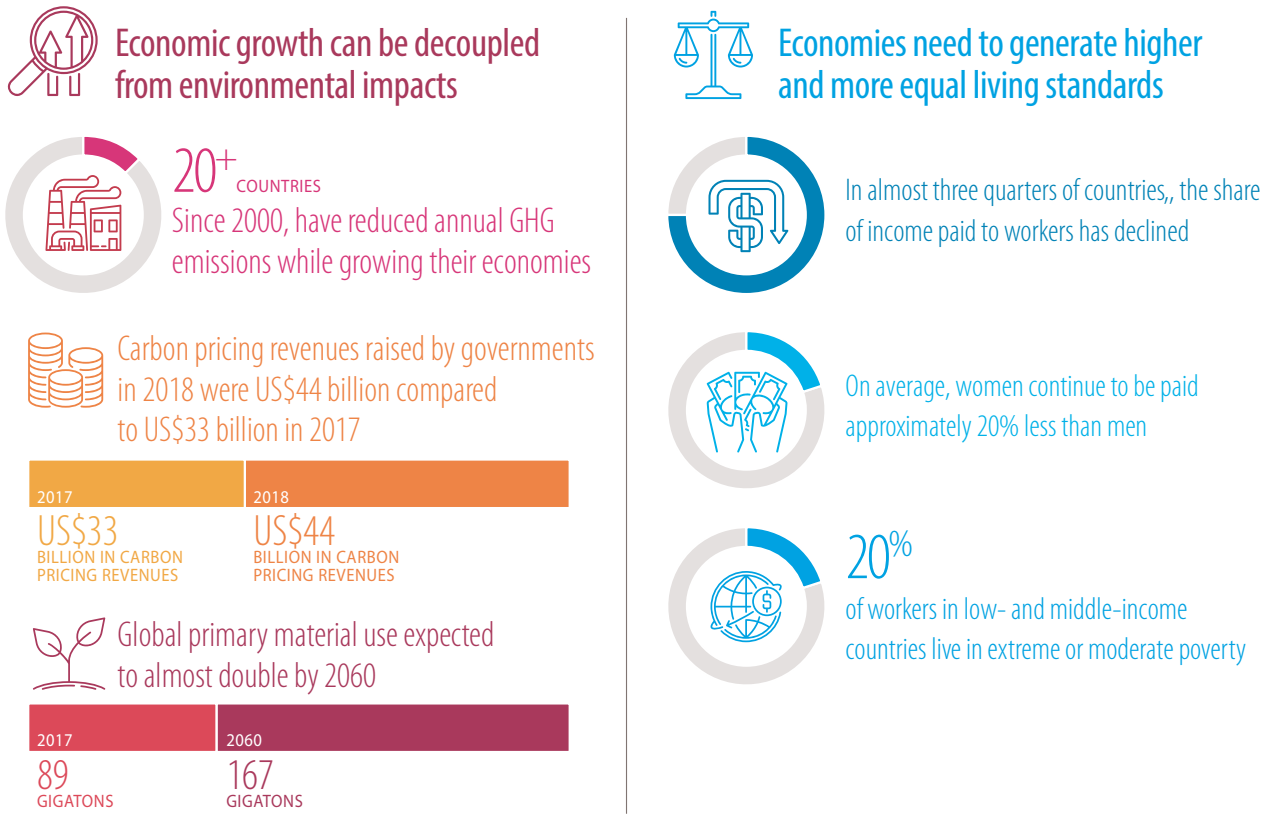
4. It is now urgent to address those aspects of economic growth and production that perpetuate deprivations, generate socioeconomic and gender inequalities, deplete the global environmental commons and threaten irreversible damage; transforming towards long-term sustainable development that maximizes positive human impacts, equalizes opportunities and minimizes environmental degradation.

Much of the behaviour of individuals, households, governments, firms and other civic entities is driven by economic incentives and systems that generate jobs, livelihoods and incomes. They fuel economic growth and generate public resources that provide basic services and public goods. Considerable effort and ingenuity go into expanding the production of goods and services – activity captured through measures such as GDP growth.

However, economic activity should be seen not as an end in itself but rather as a means for sustainably advancing human potential. What matters is not the quantity of growth but its quality. In fact, some aspects of the current organization of production could well have socially detrimental and catastrophic environmental consequences, pushing the world irreversibly beyond certain tipping points and threatening the well-being of current and future generations. Progress is also held back along other dimensions of the Sustainable Development Goals when economies widen inequalities or perpetuate inefficiencies.

This disconnect between the benefits of economic activity and its costs is not inevitable, but it can be addressed, including through remedying perverse incentives, taking full account of externalities and appropriate policies. Doing so is urgent: globally, the population is growing and living longer, and continuing to meet its aspirations for a better life is putting even greater strain on biophysical systems and societies. Decoupling the benefits of economic activity from its costs at all levels is essential in itself and can also support the systemic transformations envisaged through the other five entry points of this report. Such an outcome would greatly accelerate the reconfiguration, discussed in box 1-8, which helps put people, societies and nature on the path to sustainable development.

Figure 2-4
Sustainable and just economies: the facts

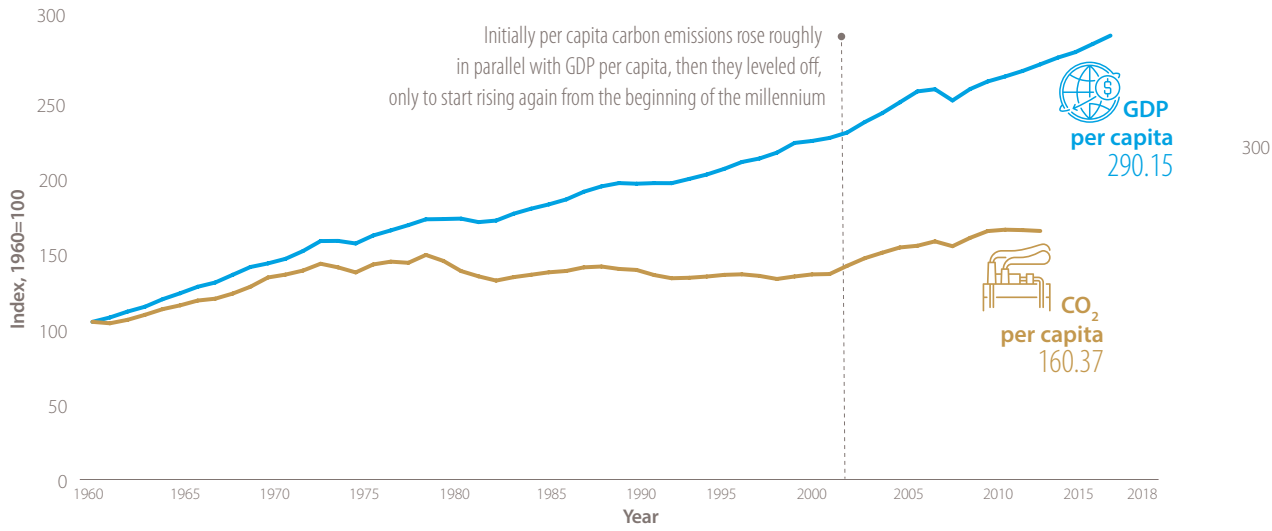


The association between economic growth and waste production, as demonstrated by per capita carbon dioxide emissions at the global level, is illustrative (see figure 2-5). In the initial period over the 1960s, per capita carbon dioxide emissions rose roughly in parallel with per capita GDP, then they levelled off, starting in about 1980, only to start rising again from the beginning of the millennium. The association between the two is the result of hundreds of thousands of decisions that are made by individuals, households

and firms in response to incentives set by the economy. At present those incentives are not being aligned with the broader objectives of the 2030 Agenda to support balanced progress in sustainable development. At the same time, such a balance is possible, as is evident from the periods when per capita GDP growth has outpaced per capita emissions growth.

Some of that misalignment results from the use of GDP growth as a driving goal in economic planning, on the assumption that other important aspects of human well-being go hand in hand with GDP. However, GDP includes values for many goods and services that do not necessarily contribute to, and are sometimes detrimental for, human well-being and exclude many that are critical elements of human progress, including healthy ecosystems and reduced inequalities.[358] Ignoring negative outcomes, such as the irreversible degradation of ecosystems, that are strongly correlated to GDP, or including economic activity that is strongly correlated to negative consequences for well-being, such as cigarette consumption, limit the usefulness of GDP as an overarching measure of human progress. Part of the necessary transformation is to use other measures to track progress (see box 2-15).

Figure 2-5:
GDP growth and CO_2 emissions per capita



A more representative measure to drive economic policymaking is needed, but achieving consensus around one that works, and is adopted across countries, may take a while.[359] Even as such work advances, countries should harness the four levers of transformation so as to attain the necessary reconfiguration towards sustainable and just economies.

Box 2-15
Alternatives to GDP as a measure of progress

GDP, which measures the market value of goods and services produced in a country in a year, aims to aggregate a country's varied economic activity into a single number. It was introduced in the aftermath of the Great Depression of the 1930s as a way of aggregating information collected through the system of national income accounts and, over the years, became ubiquitous as an indicator of overall economic health, as well as a numerical target for policy.[360] In most countries, GDP growth continues to be a primary objective of economic policy.[361]

Economic growth, however, is not an end in itself but rather a means towards improving well-being, and GDP falls short of being an adequate measure for that objective, which has multiple components.[362] For example, it fails to include the value of activities, such as unpaid care work,[363] that contribute positively to society but take place outside of the market. It cannot capture economic inequality, which can increase

Box 2-15 (continued)

along with GDP but which is ultimately inimical to societal well-being. Nor does it factor environmental impacts into economic decision-making. Hence its near-universal use to drive policy can end up constraining or even undermining the more holistic approach to priority setting and action required by the 2030 Agenda.

Those limitations are immediately apparent when one considers that economic valuations – like GDP or income – capture only one aspect of well-being. They stand out even more starkly when inter-temporal aspects are taken into account. GDP, by definition, measures only a current value, while sustainability requires also a consideration of the resources available to future generations.

There have been many alternative approaches: hybrid indices such as the human development index include the GDP as one component; green GDP, which seeks to build in aspects related to sustainability and inter-generational well-being; and subjective well-being measures. Heffetz (2014) points to the inescapable pragmatic trade-offs: what is too complex is not operational, but what is too simple is wrong. Most current thinking proposes a suite of indicators for economic decision-making, but there is as yet no clear consensus on what such a set would contain.[364]

Stiglitz-Sen-Fitoussi, for example, identify eight dimensions – material living standards (income, consumption and wealth); education; health; work and other personal activities; political voice and governance; social connections and relationships; the natural environment both now and in the future; and insecurity, both economic and physical – as key towards assessing people's well-being in a more comprehensive manner.[365] Inequalities across population groups and individuals across those dimensions are also considered important.[366] They recommend that a dashboard of indicators, rather than a single aggregate measure be used for assessing sustainability, and that those indicators are based on objective physical measures such as those measuring proximity to dangerous levels of environmental damage, such as associated with climate change or the depletion of fishing stocks).

2.6.1. Impediments

Production valuations do not account for all costs or value added – The prices charged for goods and services do not reflect the full costs of negative externalities, such as waste generated and released into the environment.[367] The harmful effects of those wastes, whether they be greenhouse gases, plastics, e-waste, or nanomaterials or other novel entities, may become apparent only after the products they are associated with come into widespread use, making it even harder to transition away from them. Corrective action is easier for impacts that are experienced immediately and are within the jurisdiction where the producer is located. Much more difficult to tackle are products for which negative impacts are slow to manifest or are widely dispersed.

Continually increasing the consumption of waste-generating goods and services is unsustainable – Consumption of goods and services is essential to human well-being, yet countries and populations are marked by wide differences both in the aggregate amounts and types of consumption undertaken. For instance, some 840 million people across the world, as of 2019, are still without access to electricity. At the same time, the per-capita electricity consumption, averaged over the five countries with the highest values for that statistic, stood at 25.62 MWh in 2016.[368]

A similar divergence is seen in the consumption of many other items, and it is reflected in the amount of resources used to meet aggregate levels of consumption in different countries. For high-income countries, the per capita material footprint – the quantity of materials that must be mobilized to meet the per capita consumption of an individual country – is 60 per cent higher than for upper-middle-income countries and 13 times that of the level of low-income countries.[369]

While boosting consumption in poorer countries and populations is essential to promote convergence in well-being, that is not a viable option at the global level, given current methods of production. According to current trends, global resource use will continue to grow, reaching over 18 tons per capita by 2060, with correspondingly increased levels of greenhouse gas emissions (43 per cent relative to 2015), industrial water withdrawals (up to 100 per cent relative to 2010) and agricultural land area (up to 20 per cent relative to 2015, with a reduction in forests by over 10 per cent and other natural habitats such as grassland and savannah by around 20 per cent).[370]

Resource use at those levels are clearly not viable. Instead, even as consumption levels rise at faster levels in poorer countries and populations, there is a need to shift consumption globally towards greener, longer-lasting and recycled, goods, as well as services that can generate sustainable development and better quality of life with a smaller environmental footprint.[371]

Inadequate investments in sustainable production – Investment needs for the Sustainable Development Goals have been variously estimated to be in the trillions of dollars per year.[372] Official development assistance amounted to $163 billion in 2017, while averaging 0.31 per cent of gross national income, less than half than the commitment of 0.7 per cent.[373] Similarly, global officially recorded remittances from migrant workers are often not available for production-related investments, although they are relatively large in aggregate terms ($626 billion in 2018, including almost $481 billion to low and middle-income countries).[374] Foreign direct investment and public sector financing can help close the gap but remains far from being sufficient. Funding needs for sustainable development will be covered only if national and international financial systems, including the private sector, direct investments towards meeting the Goals. Initiatives towards sustainable development need access to private capital at scale, with banking alone managing financial assets of almost $140 trillion worldwide, institutional investors, notably pension funds, managing over $100 trillion, and capital markets, including bond and equities, exceeding $100 trillion and $73 trillion respectively.[375] A fundamental challenge is to guide the financial system with ambition, transparency and accuracy towards the financing of sustainable development.

Costs of sharing production across jurisdictions – Globalization distributes production across various national jurisdictions, enables greater access to a wider range of goods and sparks innovation, generating jobs and reducing global poverty. However, it can also result in a race to the bottom in terms of environmental or labour standards. Critically, pollutants can also be dispersed globally, and national instruments, such as regulation or taxes, may not be available at the global level. International efforts then depend on negotiation and coordination.[376]

Governance issues are further challenged by the presence of giant corporations, often with operations across national jurisdictions themselves, and with considerable power to advance their interests.[377] Table 2-1 indicates that out of the top 30 global entities in terms of revenue, one third are corporations. The significant number of industries based on fossil fuels is indicative of one of the challenges in transitioning towards lower carbon growth paths.[378, 379]

Table 2-1
Ranking of top 30 economic units by revenue

Rank	Country/Corporation	Revenue (US$B)
1	United States of America	3363
2	China	2465
3	Japan	1696
4	Germany	1507
5	France	1288
6	United Kingdom	996
7	Italy	843
8	Brazil	632
9	Canada	595
10	Walmart (US)	482
11	Spain	461
12	Australia	421
13	State Grid (CN)	330
14	Netherlands	323
15	Republic of Korea	304
16	China Nat. Petroleum (CN)	299
17	Sinopec Group (CN)	294
18	Royal Dutch Shell (NL/GB)	272
19	Sweden	248
20	Exxon Mobil (US)	246
21	Volkswagen (DE)	237
22	Toyota Motor (JP)	237
23	Apple (US)	234
24	Belgium	232
25	BP (GB)	226
26	Mexico	224
27	Switerland	216
28	Berkshire Hathaway (US)	211
29	India	200
30	Norway	200

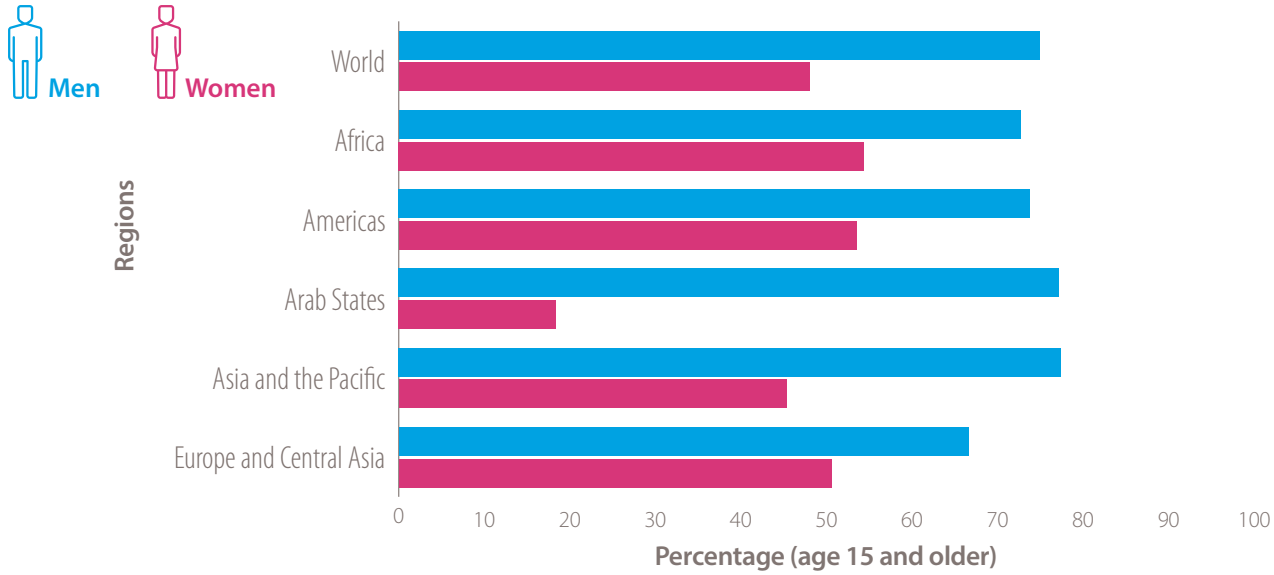
Nation States ■ Multinational companies ■

Widening inequalities in income and wealth – In recent times, economic growth has been accompanied by unprecedented increases in income and wealth disparities in many countries, driven primarily by concentration at the top of the distribution.[380] In 2017, the richest 1 per cent of the global population owned 33 per cent of the total wealth.[381] While incomes of the poorest grew, those in between – primarily middle classes in Western Europe and the USA – saw, at best, only sluggish increases. Concerns remain that increasing automation, including among skilled workers, may lead to worsening labour market outcomes for many, with ever growing concentrations of wealth and power at the top of the distribution.[382]

Gender inequality in the labour market – Women make up half the world's population, but in 2017 labour force participation rates for women were 26.5 percentage

points lower than for men (see figure 2-6).[383] Of those women who are employed in developing countries, 92 per cent are in informal employment, compared with 87 per cent of men.[384] Employment in the informal economy typically involves insecurity, lower earnings and poor working conditions. At the same time, a disproportionate burden is placed on women to provide unpaid care work in the home – women provide approximately three times the care work of men.[385] Gaps between women and men in labour force participation, the need to do hazardous work and unpaid care work are barriers to social and economic advancement.

Figure 2-6
Labour force participation rates, 2017



There is now a consensus, based on robust empirical evidence, that current levels of inequalities in many countries lower economic growth itself, making it more fragile, in addition to raising difficult social issues.[386] Inequalities also tend to become entrenched through the efforts of those at the very top to secure and perpetuate their positions through channels such as greater say in the political process, or by weakening the anti-trust and other regulatory efforts aimed at curbing monopoly power.[387] Such activities divert resources from more efficient and equitable uses and fuel scepticism among the less well-off towards the transformations that are essential for achieving the 2030 Agenda.

2.6.2. Levers for transformation

The above issues are not exhaustive, but they are illustrative of the ways in which economies can end up perpetuating unsustainable and inequitable outcomes. They will only be fully resolved by transforming economies and economic policymaking, so as to decouple growth from negative environmental and social impacts.

There is also no perfect solution for transforming economies, no single path towards sustainability and justice. Different regions and countries at different levels of income face specific sets of challenges and trade-offs, taking into account public and private interests. Each society can be guided by Agenda 2030 to assess whether economic growth strategies factor in equity and environmental perspectives, and can engage in global partnerships, cooperation and sharing of ideas. Governments can encourage dialogue among stakeholders, ensuring that economic growth contributes maximizes human well-being without causing environmental degradation or exacerbating inequality.

Action is required at all levels – national, regional and global – and may require the creation of new institutions, regulatory bodies and modes of assessing progress. That could take time, but many options can be applied immediately, even within existing social and political landscapes through the four levers for transformation.

Governance

Many of the issues can be addressed through existing instruments for coordination in national jurisdictions, which add up to a global impact. The range of instruments available for dealing with negative

externalities, for example, is summarized in table 2-2,[388] which classifies them according to whether priority is given for protecting or compensating victims of pollution or for giving incentives for polluters to reduce their damaging emissions (see box 2-16). Depending on context, different combinations of these instruments could be deployed.

Table 2-2
Policy instruments by type and by concept of rights over nature

		'Pigouvian (price-based)	'Coasian' (rights-based)	Regulatory	Legal/information/finance
	Victims	Taxes Charges, fees, tariffs	Tradable permits/ quotas (auctioned)	Bans	Strict liability Stricter financial regulation
Rights primarily allocated to	↓	Deposit-refund Refunded charges	(Green) certificates Common property resource management	Zoning Performance/technology standards	Negligence liability Financial regulation Public participation
	Polluter	Subsidies	Tradable permits/ quotas (allocated freely)	Permits	Voluntary agreements Information disclosure

Note: Most instuments here apply to both consumption and prodution, based on negative externalities. Positive, learning-by-doing spillovers require their own sets of interventions by means of technology standards, patent law, among others, that can be categorized in an analogous manner

At the global level there is currently less coordination. But a good approach is to balance top-down negotiated agreements with bottom-up local interventions, starting with small steps, using feasible instruments, testing their effectiveness and only then gradually increasing ambition.[389] That approach is being followed in implementing the Paris Agreement, by which countries can ratchet up their ambitions over successive periods of implementation and review. However, that may not produce results on the necessary scale. For example, aggregating the current commitments in the nationally determined contributions implies global warming of about 3°C (and rising) above pre-industrial levels in 2100, well below the 2°C or 1.5°C ambitions of the Paris Agreement (see box 2-17).[390]

Other approaches may involve citizen-led movements that put pressure on corporations. Where production is concentrated within a few firms in selected sectors, there is the possibility for self-regulation that will add to results at the global level. Campaigns such as Rugmark have driven out child labour from the carpet industry in South Asia.[391]

Box 2-16
Damage caused by fossil fuel subsidies

Fossil fuel subsidies are detrimental in terms of economic, social and environmental sustainability. In 2009 in Pittsburgh, Pennsylvania, G20 leaders committed to phase out, over the medium-term, inefficient fossil fuel subsidies that encouraged wasteful consumption. Those subsidies have effectively declined worldwide from $572 billion in 2012 to $296 billion in 2017.[392] However, they keep strongly encouraging consumption at higher levels than are efficient because they distort the price, which does not reflect the full societal and environmental costs. The extra use of fossil fuels due to subsidies was estimated by the same study at about $4.9 trillion in 2017.[393] Fossil fuel subsidies therefore remain a major barrier for appropriate implementation of the 2030 Agenda. Subsidies are primarily concentrated on oil and natural gas (around 70 per cent) with coal attracting less than 5 per cent.[394]

Morocco successfully implemented fossil fuel subsidy reforms through a phased approach launched in 2012 and introduced over three years until full price liberalization. The preparatory phase focused

Box 2-16 (continued)

on identifying population groups that would be affected, surveying households and businesses, and designing impact-mitigation strategies. In the second phase the government introduced partial fuel-price indexation mechanisms for diesel, gasoline and industrial fuel oil, followed by the progressive removal of subsidies for gasoline and industrial fuel oil, then for power generation, and eventually diesel, culminating in deregulated prices at the end of 2015. The incremental approach to increasing prices helped ensure a smoother transition and maintain public support for the reforms. Subsidies were eliminated first on those products more likely to be consumed in larger amounts by the wealthy, such as gasoline, while reform directed at products that would hurt the poor the most, such as liquefied petroleum gas, has been delayed. The Government also took measures to expand existing targeted social protection programmes to compensate for the welfare losses of subsidy removal. Support was also provided for public transport to compensate for the cost of higher fuel prices and to limit fare increases. Critical to the success of the approach was a large communication campaign, which built public acceptance for the reform measures. The reforms have been very effective in reducing the budget deficit while protecting the most vulnerable parts of the population. [395]

Box 2-17
Carbon pricing

Human activity in energy, agriculture, transport and industry is essential for growth and well-being, but it tends to have an important negative externality. The greenhouse gases that are emitted as by-products cause climate change. But as the market does not directly price the cost in terms of environmental and subsequent economic and social damage, far too much is produced.[396] Pricing carbon is an indispensable tool in reducing emissions of the carbon-containing greenhouse gases, particularly carbon dioxide and methane, and in enabling the decarbonization of the economy.[397] There were 74 such schemes at national and regional levels in 2018, estimated to cover about 20 per cent of total emissions.[398]

One of the more effective methods involves taxing carbon, thus raising prices of fuels and other materials that produce emissions, which results in reduction in demand.[399] Taxes raise government revenue, but they also raise prices on essential goods and services, immediately affecting the less well-off and could potentially reduce profits for large industries. Unless alleviated in some way, the potential price increases due to the tax can mobilize powerful political opposition. Consequently, taxes also tend to be too low: a recent survey of climate scientists and economists concluded that the initial rate would have to be in the range of \$150 to \$300 per ton of CO_2 (rising over time until the necessary reductions are achieved)[400] to drive a sufficiently large decrease in use. At present, the actual global carbon price is at most a tenth of this range – and close to zero in many countries that may have introduced such schemes.[401]

One approach that works around the issue of political opposition to price increases is one in which all or most of the revenue from the tax is refunded to voters. Switzerland, for example, rebates two thirds of the revenue collected back to households and firms. Even a sizable tax could become acceptable if the dividend back to citizens – particularly those least able to deal with the rise in prices – was large enough to offset increased costs of living.[402] A group of 45 leading economists from across the political spectrum in the United States initiated a call for such a mechanism to be put into place.[403] Similar calls have been addressed to public opinion in many countries. Sufficiently high – and consistent – taxes can also minimize regulatory burdens besides providing price signals that serve as incentives towards innovation and investment towards decarbonization and more sustainable economic growth.

Regulations to drive innovation – Regulations that become progressively more stringent can stimulate innovations that lead to more efficient resource use, reduced production of wastes, and cessation of the use of certain materials such as hydrochlorofluorocarbons (HCFCs) that damage the ozone layer. Life cycle assessments can help determine limits in that regard. Other practical approaches include cap-and-trade regulations, such as the European Union's Emissions Trading Scheme, which set a limit on the total amounts produced in the economy but leave it to the market to determine the amounts produced by individual firms. Regulations are critical where production is dispersed across many units, as with small enterprises in many developing economies. If they are encouraged to adopt state-of-the-art production technologies, micro, small and medium enterprises can be at the forefront of sustainability transitions, including through technology transfers mediated by industry associations or government departments. Such regulations must also contend with possible negative impacts on workers and communities, calling for proactive policies for just transitions.[404]

Proactive policies for just transitions – Transitions towards sustainability can have significant impacts on employment, workers' families and communities, reducing or eliminating jobs in polluting industries and creating jobs using modern cleaner production.[405] The deployment of new technologies and automated production that are part of such transitions can also reduce total labour demand even for skilled workers.[406] That trade-off may be beneficial for the environment and for society at large, but it comes with human costs for affected workers, their families and immediate communities. To make those transitions socially acceptable, it is essential to take into account the millions currently employed in resource intensive sectors (see table 2-3) and others who will lose their jobs. In many countries, employment in resource-intensive sectors like energy is decent, unionized and relatively high paying, which contributes to anxiety about job losses that must be met through offering social protection coverage, re-skilling programmes, practical transition options and support to bolster communities (see box 2-18).

Table 2-3
Greenhouse gas emissions and employment by sector

Sector	Share of global anthropogenic greenhouse gas emissions (%)	People directly employed (millions)
Energy, including electricty and heat	34.6	30
Agriculture, forestry and other land use	24.0	1,044
Industry	21.0	200[b]
Transport	14.0	88
Building	6.4	110

Note: The value reported for employment in industry is estimated for resource-intensive industries only. The actual number for the sector is larger.

For example, agriculture employs more than 1 billion people worldwide.[407] Increasing agricultural production using sustainable techniques can reduce greenhouse gas emissions, help to meet the demand for food from a growing population and sustain rural jobs. That can be achieved, for example, by improving crop varieties, reducing food waste, adopting more sustainable agroecological practices and using fertilizer and water more efficiently, but the transition also requires investments in training and agricultural extension. Likewise, prioritizing electricity for all, using renewable energy technologies like photovoltaics, opens options for entrepreneurship while reducing greenhouse gas emissions from carbon-based energy systems.

Economy and finance

Incentives direct private capital towards more sustainable production – Infrastructure can endure for decades, so it is vital to direct such investments towards sustainable and socially responsible ends. Governments can do so within public expenditure and procurement,

Box 2-18
Just transition for coal workers and communities[408]

Canada has committed to phasing out coal-fired electricity by 2030. In 2015, it accounted for 11 per cent of the electricity produced and 78 per cent of the sector's greenhouse gas emissions. Its Task Force on Just Transition for Canadian Coal Power Workers and Communities (2018) estimated that it would affect nearly 50 communities, 3,000 to 3,900 workers, over a dozen generating stations and nine mines. It would accelerate a transition that had already commenced in the country.

Through a series of consultations with affected stakeholders, the task force identified seven principles for a just transition, including respect for workers, unions, communities and families; worker participation at every stage of the transition; immediate yet durable support; and nationally coherent, regionally driven and locally delivered actions.

Its 10 recommendations are clustered around six areas:

- Embedding the just transition principles in planning, legislative, regulatory and advisory processes to ensure ongoing and concrete actions throughout the transition;
- Ensuring locally available supports, such as transition centres in affected communities;
- Providing a pathway to retirement through a pension bridging programme for those retiring earlier than planned due to the transition;
- Enabling the transition of those remaining in the labour market across the various stages of securing a new job including with access to information, income support, education and skills building, re-employment and mobility;
- Investing in community infrastructure;
- Funding community planning, collaboration, diversification and stabilization.

as well as through regulation and by providing incentives through tax breaks. But the private sector itself, can also direct investments in more productive directions, using environmental, social and governance standards aligned with the Sustainable Development Goals. While interest in such transitions is growing, it is not happening rapidly enough to be effective. A Sustainable Development Investment label would allow an assessment of the existing flows contributing to the achievement of the Sustainable Development Goals in proportion to the total annual global investment, provide a technically robust classification system to establish market clarity on what is sustainable and help to channel capital flows towards assets that contribute to sustainable development. Establishment of the Sustainable Development Investment label therefore requires an international platform, where labelled solutions and investors, as well as relevant information providers, can come together. That platform should also guide a work programme to advance labelling methods and extend information sources.

Fiscal systems can facilitate fair redistribution – Redistributive strategies are already a means to achieve the Goal 10 target on inequality. Governments should agree on explicit quantitative targets in reducing income inequalities in favour of the worse-off. Fiscal policy – raising revenue through taxes and directing public expenditures to specific ends – can promote equity, finance public goods and communicate priorities with which the private sectors and others can align themselves. Systematic empirical studies[409] from across a range of countries have established that redistribution does not hurt growth, and so strengthens the potential contribution of fiscal policy in this context. However, both the progressivity of the tax system (i.e., the extent to which wealthier parts of society finance a greater proportion of public goods) and the alignment of expenditures with inequality reduction have to be considered together for overall effect on inequality. In general, more can be done to improve tax progressivity in all countries. In OECD countries, the top personal income tax rate fell from an average of 62 per cent in 1981 to 35 per cent in 2015.[410] In developing countries lower tax capacity, informality, especially at the upper ends of the income distribution, and a larger share of indirect taxes all contribute to less progressive systems.

Over the last few years, the median tax revenue, as percentage of GDP, for most country categories (developed countries, least developed countries, middle income countries and small island developing States) have been following a rising trend since the end of the world financial and economic crisis.[411] Applying those

increasing revenues towards redistribution (quality health and education services and social protection systems), while also improving the progressivity of tax systems and reducing tax avoidance, will deliver greater benefits for society while strengthening sustainable economic growth.[412]

International collaboration on taxes is also important, particularly as much economic activity is spread across national jurisdictions, thus enabling trans-boundary corporations to avoid taxes through base erosion and profit shifting, which is the systematic reporting of profit in jurisdictions with lower tax rates.[413] Exchanging tax information across countries is a starting point towards combating tax evasion. At the same time, other illicit financial flows, such as corruption and the transfer of proceeds from crime, which have especially significant consequences for economic, social and political stability, also require international collaboration. While reliable estimates for those are hard to come by, greater transparency, collaboration and the creative use of technology are all necessary for curbing tax evasion and other illicit financial flows.[414]

Public sector research and development – Market price signals do not necessarily result in the best investment decisions for research and development from a longer term, sustainability oriented perspective.[415] In that case the public sector may need to step in, either through research within public institutions, such as universities and other public research organizations, or by subsidizing private sector research in key areas, such as disease prevention and control or climate change mitigation and adaptation. The aim should be to drive down costs and make the new technologies competitive with the older ones. In the case of climate-related technologies, active early intervention towards their development and deployment through research subsidies is less costly, and also reduces the amount of carbon taxes needed to make the shift.[416] In addition to research and development investment in sustainability-related technologies, the public sector can play a role in supporting the commercialization, diffusion and adoption of these technologies at a broader level.

Individual and collective action

Reducing waste-oriented demand and promoting responsible consumption – In many developed economies most basic consumption needs have been met, while material footprints are large.[417] The aim now should be to enhance well-being while lowering the material footprint. Norms that encourage this include repair and reuse as well as collaboration and sharing. Social movements towards these ends, especially among the youth, can incentivize business models incorporating longer product cycles and product warranties along with and slower rates of obsolescence. Those can bring about lasting change in how economies function.

Workers as agents of change – During previous eras of technological change, workers' organizations helped ensure that conditions at work improved, and wages rose so that productivity gains were more widely distributed, and social cohesion strengthened. They could continue to play such roles in the near future; however, a broader coalition including governments and employers could be more effective, especially given the decline of workforce participation in labour unions in many countries and sectors.[418] Disruptive new technologies and globalization indicate that significant numbers of people may work as self-employed workers, or under non-standard labour contracts, for example in platform labour markets like drivers for car-hailing services. With those trends in mind, the ILO's Commission on the Future of Work has recommended measures, such as universal labour guarantees to cover all workers irrespective of contractual status, and governance systems for labour platforms.[419] In those contexts, too, the freedom to organize can enhance worker agency and generate more bargaining power for workers, if it is accompanied by the evolution of innovative worker organizations.[420]

Change social norms and laws that limit women's labour participation and perpetuate other differences at work – It is important to revise incentives to move towards gender parity of opportunities in work. That should include expanding options for care services for the elderly and for young children, providing and encouraging paternity leave and encouraging men's engagement in unpaid work, while removing wage and hiring discrimination in paid work for women. Likewise, it is important to increase security in informal work, for example through ratification of the Convention on Decent Work for Domestic Workers.[421]

Science and technology

Technologies may help resolve trade-offs, but holistic assessments are needed – Many new technologies have the potential to mitigate trade-offs between production and the environment. For example, energy production is becoming more sustainable and cheaper through innovation in, for instance, nanotechnology for solar panels.[422] Solar power is now cost-competitive

with energy generated from fossil fuels. Meanwhile, renewable off-grid solutions provide alternatives to costly network extensions and can therefore electrify remote areas more efficiently and quickly.[423] Hence energy production is becoming more equitable and sustainable.

On the demand side, a smartphone, for example, can now provide in one machine the services previously offered by numerous separate devices, thus potentially reducing total energy demand, if also serving to replace the use of those devices by the consumer.[424] Emerging technologies such as artificial intelligence, the "Internet of things" and blockchains are bringing forward applications that can accelerate the transition away from inefficient and polluting production and consumption[425] – for example, through electric vehicle fleets or improved, remotely controlled thermostats that manage household heating and cooling more efficiently.[426,]

But such innovations need not translate into reduced aggregate demand if consumers respond to greater efficiency by simply consuming more or if they come with damaging side effects. For example, a car-hailing service operating with electric cars should reduce the carbon footprint per ride. But it may add to total emissions if it draws passengers away from more efficient and more broadly accessible public transport systems and increases traffic congestion. [427] New technologies, including smartphones, may also introduce new pollutants – novel substances – into the Earth system, for which existing processing capacities may be inadequate. Applications such as blockchain and cloud computing also make large energy demands. Added concerns arise when more efficient production results in lost jobs and workers whose skills may become redundant.

2.6.3. Integrated pathways to transformation

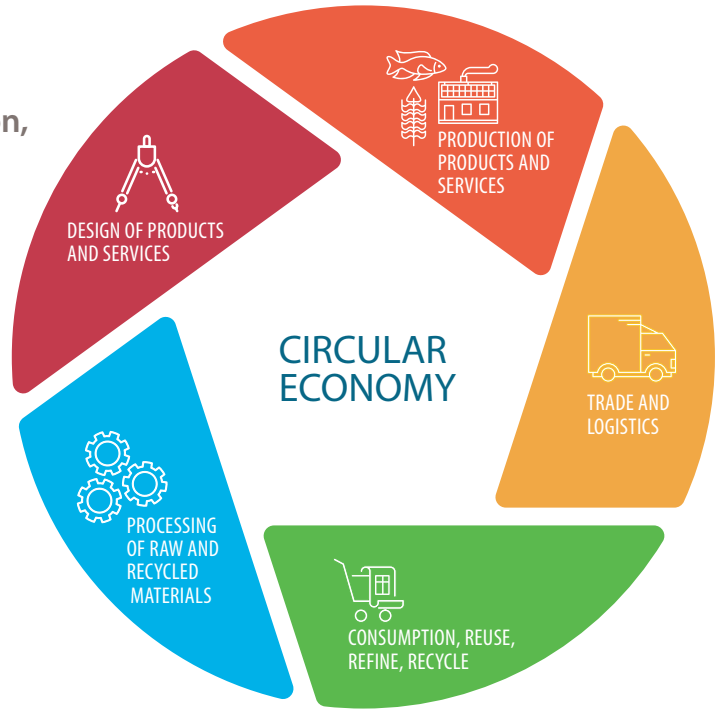
Using those levers requires action on multiple fronts, through engaging governments, the private sector, individuals and society, as well as the science and technology community. Short-term changes or local initiatives should be seen as the first steps along a path to the long-term goal of sustainable development. In the context of climate change, government action in pricing carbon, coupled with a people-centred approach to transformation, complements private sector leadership in innovation and investment to help create economies where development is inclusive, sustainable, strong and balanced. [428] One model for guiding decision-making is the concept of a circular economy, in which waste management and upstream product design and service development are planned to extend product lifetimes and reduce the use of natural resources (see figure 2-7), while creating jobs and helping reduce poverty.[429] In developing countries, particularly in Asia and Africa, micro, small and medium enterprises generate livelihoods and work and, when following the circular economy model, can help mitigate trade-offs with the environment as well.

Transitions away from business-as-usual pathways involve winners and losers in the short term, which must be taken into account (see box 2-19). Yet another example, as the world makes the critical transition from fossil fuels to renewable energy, city and business leaders will need to deal with "stranded assets", that are rendered obsolete even if they are still operationally viable. Stranded assets could be minerals that remain in the ground, infrastructure designed for traditional energy production, training for jobs based on fossil fuels (see box 2-20). In those cases, it is important to change the frame of reference regarding them not as asset but as liabilities, ensuring that the costs and risks are fairly assigned. The Group of 20 has charged its Financial Stability Board to propose an approach to the issue that maximizes transparency and effectiveness.[430] Incentive structures towards a circular economy must also consider the impacts on poor and marginalized groups and ensure that transitions do not push them further behind.

Figure 2-7:
The circular economy[431]

BENEFITS

- Minimized pollution, climate emission, waste and use of raw materials
- Preservation of natural systems
- Increased competitiveness
- New markets
- Employment opportunities
- Social benefits



Box 2-19
Addressing the needs of the poor in a circular economy

While transitioning to more sustainable economies, governments should take care to safeguard the interests of the poor, thereby ensuring that the transition is a just one.[432] For example, they could use carbon tax revenue to finance poverty alleviation programmes and make climate policy progressive by compensating low-income households; introduce and strengthen carbon pricing; invest in low-carbon infrastructure; introduce payments for environmental services that help the rural poor while achieving environmental goals such as reducing deforestation; and adopt employment guarantee schemes that, alongside guaranteeing labour and income to households in poverty, help build energy and environmentally friendly infrastructure.[433]

Brazil has historically been proactive in many of those areas by committing to emissions reduction and actively tackling poverty. One example is Bolsa Verde, a programme for ecological services payments (giving cash transfers to the rural poorest in exchange for forest protection). Yet another is the concessions given to electricity distribution companies based on the commitment to electrify the poorer and isolated areas.[434] Studies have shown that providing access to modern energy through direct policies is significantly more efficient than relying on economic development to reach the poorest segments of the population.[435]

Box 2-20

Stranded assets

Stranded assets are assets that prematurely became obsolete or non-performing and must therefore be written off. They can appear as a result of government policies, technological change, shift in demand due to changing social norms and similar factors.

Environmental concerns and especially climate change challenges can drive this phenomenon: in order to stay within 1.5°C warming above the pre-industrial level with a probability higher than 66 per cent, the Special Report on Global Warming of 1.5 °C of the International Panel on Climate Change estimated that the world should emit no more than 420 gigatons of CO_2, which is about eight times less than would be possible if the known fossil fuel reserves were burned.[436, 437] That implies that 80 to 90 per cent of global oil, gas and coal reserves should remain unused,[438] and a majority of fossil fuel reserves, as well as related capital assets, are going to become stranded assets. As a result, companies that have made massive investments into accessing fossil fuel reserves and built required infrastructure may not ever be able to extract those reserves and repay their debt. Governments that own fossil fuel reserves also lose sovereign bond value.[439]

Downstream sectors, such as power generation, buildings and industry will also experience stranding of their assets. In power generation and industry, stranded assets are fossil fuel power plants or industrial equipment that should be shut down or become obsolete before the end of their anticipated technical lifetimes owing to climate requirements.

According to estimates by the International Renewable Energy Agency, even if policy actions are taken immediately, cumulative stranded assets in 2015–2050 will account for approximately $5 trillion in buildings, $4 trillion in the upstream sector and $1 trillion in industry and power generation. Delayed policy action (i.e., no policy action until 2030) will result in costs at least twice as high for all the sectors.[440]

Accumulation of stranded assets has the potential to cause financial instability.[441] A study shows that exposure of European Union financial institutions to firms holding fossil fuel reserves and to fossil fuel commodities exceed 1 trillion euros.[442]

Policy actions are needed to disincentive investment into assets that are likely to become stranded. They include higher carbon prices, tighter regulations, encouraging industry to invest in retrofitting and energy efficiency improvements through tax incentives, regulatory standards and concessional finance. Given the exposure of the financial sector, the problem also requires attention from financial regulators. Some recommendations include extending stress tests required by regulators to environment-related risks driving stranded assets and higher capital requirements for assets with greater levels of exposure to environment-related risks.[443]

Companies exposed to such risk factors should also pay more attention to managing them. One way to reduce the risk from those factors is to use financial securities and other financing mechanism, such as catastrophe bonds, national or international insurance pools and programmes and contingent credit.

2.7 Entry point 3 – Food systems and nutrition patterns

Key messages

1. Upscaling current food production practices to meet the projected food demand of the world's population in 2050 would be completely incompatible with meeting the Paris Agreement as well as many of the Sustainable Development Goals.

2. In transitioning towards sustainable food systems, the focus must be on enabling more equitable global access to nutritional foods, reducing food loss and waste and maximizing the nutritional value of produce while, at the same time, minimizing the climate and environmental impacts of production and increasing the resilience of food systems.

3. Changes to food systems need to include climate change and health considerations to increase the resilience of food systems for food security and human health and ensure that access to nutritional foods is not disrupted.

4. Technological innovation is a prerequisite for the transition to sustainable food systems, but on its own it cannot deliver the transition without changes in governance, behaviour and economic incentives.

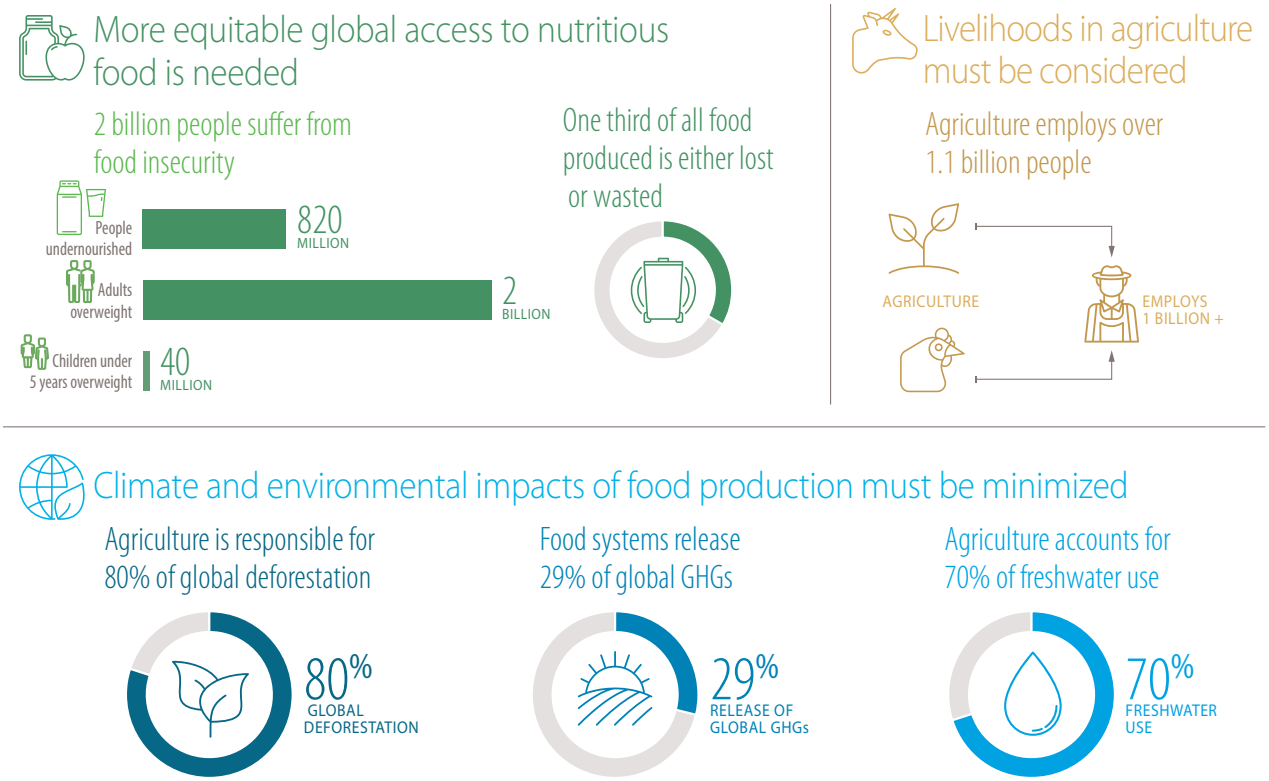
The global food system comprises many local and regional food systems and includes not only food production but also all other food-related activities, as well as how those activities interact with the Earth's natural resources and processes.[444, 445] Because of its climate and environmental impacts and shortcomings in healthy, safe nutrition for all, today's global food system is unsustainable.[446] Moreover, it does not guarantee healthy food patterns for the world's population. It is estimated that more than 820 million people are still hungry. At the same time, rising obesity and overweight is seen in almost all regions of the world. Globally, 2 billion adults are overweight as are 40 million children under the age of 5.[447]

Scaling up the food system as it exists today to feed a growing global population through the year 2050 and beyond, while sustainably accommodating non-food agricultural commodities is an overarching concern (see figure 2-8).[448, 449] However, under business-as-usual scenarios, an estimated 637 million people will be undernourished,[450] and the environmental impacts of increased production would eliminate any chance of achieving the goals of Agenda 2030.[451] Additionally, pests and crop diseases put global food supplies at risk, but managing them with increased use of chemical inputs could jeopardize many environment-related Sustainable Development Goals.[452] Thus, business-as-usual pathways and upscaling of current practices are not options if the global food system is to sustainably and equitably meet the needs of the global population in the future. Fortunately, however, the challenge of transitioning food systems onto a sustainable trajectory is not insurmountable. Recent studies[453] describe food systems capable of delivering nutritious food for a global population of 9 to 10 billion with greatly reduced environmental impacts. Transitioning to sustainable food systems requires technological innovation, strategic use of economic incentives, new forms of governance and changes in values and behaviour.[454, 455]

Ultimately, transformation of the global food system must lead to ending hunger and malnutrition (Goal 2) while at the same time addressing water scarcities (Goal 6), reducing climate impacts (Goal 13) and protecting life in water and on land (Goal 14 and Goal 15). Focus on increased production alone, will make it impossible to meet the associated targets. Failure to focus on the environmental impacts of food production will result in negative feedbacks on food systems, that is, water shortages, extreme weather events, soil infertility and possible changes in the nutritional quality of produce[456] that will render the achievement of Goal 2 itself impossible.

Figure 2-8

Food systems and nutrition patterns: changing food systems is essential for sustainable development



2.7.1. Impediments

Transitioning to sustainable food systems faces numerous immediate barriers:

Institutional deficits – To ensure that no one is left behind, much of the increase in food production will have to come from the 750 million smallholder farmers that estimates show will be operating in 2030.[457] At present, those farmers have little access to institutional, legal or financial support. Furthermore, investments in infrastructure (communication routes and storage and processing facilities) often benefit larger production units, particularly those involved in global supply chains, rather than small-scale farmers.[458] Another concern is fluctuating food prices, which is especially concerning for poorer households, which spend a relatively high proportion of their incomes on food.[459] Even net-food sellers are exposed to such volatility because their bargaining position in food chains is weak, and they do not capture the benefits from higher prices.[460]

Concentration of ownership – Although there are many economic actors in the global food market, many of its components are controlled by a relatively small number of actors.[461] Around 60 per cent of the commercial seed market is under the control of six companies, along with around three quarters of the pesticide market. Four companies account for up to 90 per cent of the global grain trade.[462] Concentration runs the risk of reducing the resilience of the global food system, by generating uniformity in industrial agricultural practice.[463] Furthermore, the concentration of trade and production can be an impediment to small-scale farmers.

Damaging agricultural practices – Some widespread practices in food production cause damage to agricultural soil. Billions of hectares of land have already been degraded, and an additional 12 million hectares of agricultural land annually are likely to become unusable for food production every year.[464] Soil degradation is in direct conflict with the concept of intergenerational equity introduced in the Bruntland Report.[465] In addition, agricultural practices can lead to eutrophication of aquatic environments, groundwater contamination, soil acidification and atmospheric pollution.[466] They were also responsible for 60 per cent of global emissions of the greenhouse gas N_2O in 2011, although the share of N_2O from agriculture seems to be decreasing.[467] When all emissions associated with the global food system are considered, they account

for more than 19 to 29 per cent of total greenhouse gas emissions.[468] Without technological improvements or other forms of mitigation, especially restoration of soil health in order to increase its carbon content, greenhouse gas emissions from global agriculture could rise by as much as 87 per cent if production is simply increased to meet the demands of the global population in 2050.[469] That scenario is incompatible with the Paris Agreement and Goal 13.

Wasteful food systems and food loss – Historically, food consumption patterns have mirrored the rhythm of the seasons. In a global food market, seasonal and geographical variations in food commodity availability are greatly reduced. That has led to new eating habits in many countries. The transport and storage necessary to support those new habits have, however, given rise to increasing greenhouse gas emissions and food waste.[470] Moreover, around one third of all food produced for human consumption is lost or wasted, a consequence both of poor logistics, particularly for the local processing and transport of perishable crops, exposure to pests and disease exacerbated by climate change, and of marketing practices that rely on long periods of transport and storage and encourage consumers to buy more food than they can use.[471] The Food and Agriculture Organization of the United Nations (FAO) has found that global food loss and waste is responsible for annual greenhouse gas emissions surpassed only by the national emissions of China and the United States.[472]

Threats to food security – Global plant and animal diseases pose a threat to food security (see box 2-21). Climate change is increasing the scale at which new pests and diseases emerge, and pests are being moved more rapidly between countries with increased trade. Additionally, habitat changes are linked to agricultural intensification. Thus, dietary habits, climate change and human health are all intricately interconnected. The current world food system presents a huge challenge to policymakers, but there is also potential for change through the four levers for transformation.[473]

Box 2-21
Global surveillance system for crop diseases[474]

At the global level, yield losses caused by pests and diseases are estimated to average 21.5 per cent in wheat, 30.0 per cent in rice, 22.6 per cent in maize, 17.2 per cent in potatoes and 21.4 per cent in soybeans. Those crops constitute half of the global human calorie intake. The distribution, host range, and impact of plant diseases is driven by climate change and global trade, while many of them can spread or re-emerge after having been under control. While many national and regional plant-protection organizations monitor and contain crop disease outbreaks, many countries, especially low-income countries, lack in efficiently exchanging information, thus delaying coordinated transnational responses to avoid disease establishment and spread.

The International Plant Protection Convention was adopted in 1951 and allows participating countries in national and regional plant-protection organizations to collaborate in order to improve the awareness of threats to agriculture from the entry and spread of regulated pests and pathogens. It comprises 183 national organizations and 10 regional organizations, in cooperation with the Convention Secretariat and the Commission on Phytosanitary Measures, and it experiences many challenges, including dealing with a high number of regulated pests (approximately 400 in Europe alone), with limited resources.

Major advances have been made in disease diagnostics in the past decade, particularly through genome sequencing; CRISPR-based diagnostics; bioinformatics tools for genomic epidemiology, genomic prediction, data mining, data analysis, and modeling; and development of social media platforms for information sharing. These advances will transform the speed, accuracy, and wealth of information collected during disease outbreaks. Mobile and Real-time Plant Disease diagnostics, for example, is a near real-time, genomics-based, point-of-care diagnostics platform for wheat yellow rust, which directly informs disease risk forecasting in Ethiopia.

To be more prepared against unexpected crop-disease spread, scientists have proposed the establishment of a global surveillance system that could bring established biosecurity practices and networking facilities to low-income countries, thus allowing them to quickly respond to emerging disease outbreaks and to stabilize food supplies. The global surveillance system model is based on lessons learned from previous outbreaks, regional plant protection efforts and best practices implemented in high-income countries.[475]

2.7.2. Levers for transformation

Governance

Good governance, with the inclusion of multilevel actors, is key to transforming food systems. Important areas of focus are the following: monitoring and correction of land ownership rights to avoid excessive land concentration and ensure that a new generation of farmers can emerge without facing the obstacle of unaffordable prices for land; strengthening land tenure, the level and targeting of public investments towards public goods rather than, for example, the subsidization of energy-intensive inputs;[476] the ability of the state to prevent conflict; water rights, including access to irrigation and groundwater; and risk prevention initiatives to increase resilience against food crises.

Social protection floors – Stronger social protection floors and other social programmes can help vulnerable populations become more food secure. In order to increase resilience in agricultural production, governments, in partnerships with the private sector, can protect farmers and their livelihoods to help them withstand and recover from environmental shocks and the social and economic repercussions that follow.[477, 478]

Legislation – Legislation can minimize ecosystem degradation, protect ecosystem services and rehabilitate degraded environments, including by rewarding protection of ecosystem services and discouraging negative impacts on the environment and on health that are caused by unsustainable farming and manufacturing practices.[479]

Supply chains – Governments can improve processes of certification and labelling for sustainable food production. This will reduce transaction costs for producers, improve monitoring practices, increase consumer awareness and ensure overall greater transparency within food supply chains. Certification can be achieved using participatory methods so as to ensure it is appropriate, but more efforts are needed to make such schemes scalable.[480] Small-scale farmers should be supported in order to ensure such processes and regulatory constraints do not negatively impact their ability to enter supply chains.

Gender parity – Whereas agricultural production is increasingly feminized, agricultural and food policies, including training and research and development, do not take into account the specific needs of women. That is a considerable missed opportunity.[481] Women have limited access to decision-making processes of resource management and have less access to resources that increase agricultural output.[482] The rights of women and their active participation within agricultural production, and throughout the supply chain, need to be addressed and secured. Strengthening the voice of women and girls in the production, purchase and distribution of food, and increasing the control women and girls have over decisions about infant feeding is strongly needed. For instance, agricultural extension services that support farmers in applying new techniques and technologies should consciously account for gender roles in agricultural and rural development, including through the recruitment of female agricultural extension workers.[483]

Economy and finance

From the local to the global level, food systems are driven by economic and financial mechanisms. Transformations in the economic and financial sectors can redirect food supply chains towards a sustainable trajectory. This will require participation from governments, business and civil society.

Insurance – Reliable insurance opportunities are important to help small-scale farmers withstand and recover from environmental shocks. The use of parametric or index-linked insurance for small farmers, especially in areas subject to climate-related hazards, is one option that has met with success in some contexts.[484]

One such scheme for cotton farmers in Mali and Burkina Faso indicates risk may have been reduced and farmers were encouraged to invest more and produce more.[485] Nongovernmental organizations (NGOs), such as World Cover, are implementing pilot schemes.[486] Science and technology support those schemes in several ways. Cell phones can be used for registration and participation in such schemes. In some countries, payments can be made to the participant's phone. For most index schemes, remote-sensing data is used to monitor weather and meteorological events to determine whether triggers are reached. The application of blockchain technology to such schemes can make much of the process automatic and allow for payment to eligible participants once the trigger point has been passed.[487]

Trade agreements – Trade agreements should incorporate economic, social and environmental concerns throughout food supply chains. Trade policies can help reduce inequalities (Goal 10) and create decent work and inclusive economic growth (Goal 8), as well as contribute to climate action (Goal 13), but only if such policies are made coherent with those goals and take into account core conventions of the International Labour Organization and multilateral environmental agreements.[488]

Market access – Agroecological systems based on small- and medium-scale farms that have temporal

and spatial diversification and locally adapted varieties and breeds can respond to environmental stress.[489] But to compete with the output of industrial agricultural systems, small-scale farmers need better access to markets, groundwater and irrigation, credit and finance.

Individual and collective action

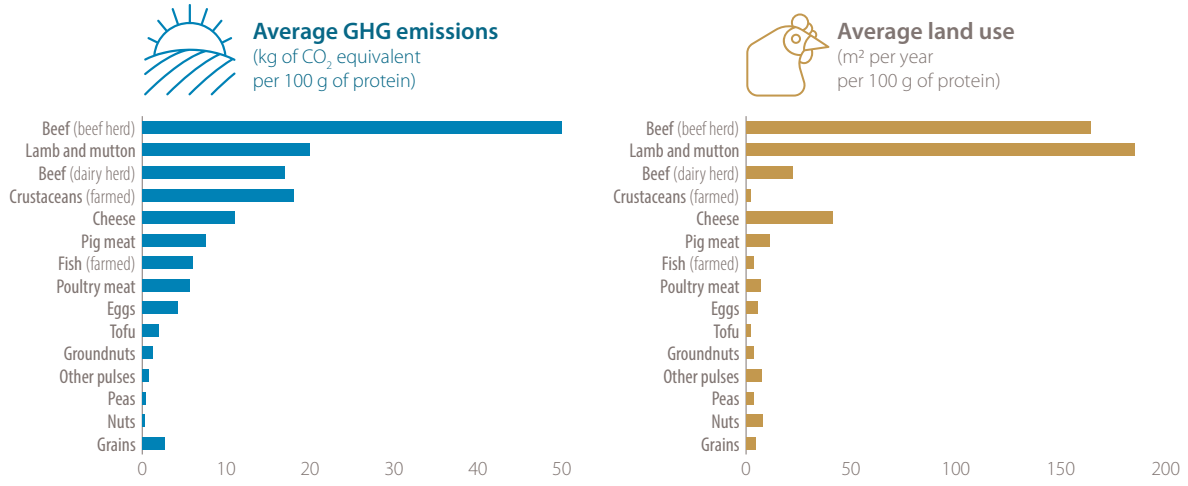
Transforming the food systems requires changes in behaviour by consumers, producers and distributors. That may require challenging social norms and cultural practices while making it easier and less costly for the relevant actors to make responsible decisions regarding sustainable lifestyles.

Food waste – Reducing waste must be based on increasing consumer and retail awareness of purchasing patterns, challenging some dominant cultural norms and expectations and in some cases changing legislation.[490] Addressing power imbalances in food chains in order to ensure retailers and food manufacturers are not allowed to impose on their suppliers to deliver more than required goes a long way towards meeting this challenge.

Nutrition – The implementation of nutrition policies and provision of integrated food and nutritional support and services, with special attention to the needs of women, girls, infants and young children, can help support better health outcomes and improve choices for individuals. Such policies should ensure access to sufficient, safe and nutritious food to meet dietary needs and food requirements for an active and healthy life, and should support adequate care and optimal feeding practices, especially during pregnancy, lactation and infancy, when nutritional requirements are increased.

Dietary habits – In many developed countries, consumers could reduce the demand for animal products and improve their health by eating less meat, that is, adopting meat-light or meat-free diets. In many developing countries a shift away from staples to other nutritious foods would improve nutrition. Shifts in dietary habits are thus context specific. Food consumption patterns can be changed from an early age through education on sustainable and nutritious diets and can also be achieved by involving the private sector to reduce the promotion and advertising of ultra-processed foods. The environmental impact of various forms of food is illustrated in figure 2-9.[491]

Figure 2-9:
Impact of food on the environment: selected proteins



Note: Data are the mean values from approximately 38,700 commercially viable farms in 119 countries. Grains are shown here as they contribute 41 per cent of global protein intake, despite lower protein content.

Science and technology

New technology can optimize food production and distribution and offer innovative solutions to food-system challenges.

Lower environmental impacts and better nutrition – A focus on technological development that can lead to maximizing the nutritional value of food produced with respect to environmental impact of production is a prerequisite for developing a sustainable global food system. That includes approaches that can increase production per unit land area, decrease water use and decrease or eliminate the release of both pesticides and reactive nitrogen and phosphorous into the environment.[492] There is evidence that

organic farming, which does not rely on the use of artificial fertilizers and pesticides, may be able to make significant contributions to the transition of some food systems.[493] Abstention from the use of artificial fertilizers often leads to reduced yields compared with conventional farming practices. However, studies that compare yields between conventional and organic farming practices indicate that the performance of the two forms of farming is very context specific and that organic farming does not consistently underperform in comparison with conventional practices.[494]

It can also be noted that research on maximizing yield in conventional agriculture has been carried out much longer than in organic farming and other forms of agroecology. Given the much-reduced environmental impacts associated with the later production forms,[495] further research directed towards maximizing yields should be carried out. Finally, any change in practices or technological innovation that can lead to an increase in the soil carbon pool both increases soil fertility and contributes to the mitigation of climate change. The international 4 per 1000 initiative, which is concerned with soils for food security and the climate, aims to increase soil organic matter content and carbon sequestration through the implementation of agricultural practices adapted to local environmental, social and economic conditions, as proposed in particular by agroecology, agroforestry, conservation agriculture or landscape management.[496]

Genetically modified organisms can also potentially contribute to increasing the efficiency of food production and crop varieties that are tolerant to pests, diseases, drought, floods and salinity. However, the benefits of genetically modified organisms to food production are highly context specific.[497] There are also considerations around biosafety, that is, potential negative effects of the exposure of genetically modified organisms to natural ecosystems and their deployment in highly industrialized mono-crop culturing systems that can erode biodiversity and often degrade soil health, and, so far, have had low contribution to creating employment in rural areas, where costs of seeds remain high.[498]

The approach to sustainable agriculture or food systems should be to keep the focus on outcome goals, such as improved nutrition and reduced food insecurity, reduced land and input use, reduced environmental externalities, and improved farmer livelihoods. Given that socioeconomic and agroecological factors vary widely, there is not one production system or approach for achieving these goals. In some cases, sustainable intensification and precision agriculture will be the best approach, in others, organic or agroecology systems, as key elements of a climate smart approach to agriculture, will provide the greatest net benefits.

Information systems – Farmers can reduce on-farm losses and become more resilient if they have better access to market information, along with data on climate and production. An agroecological approach would entail thorough data collection and research to identify areas best suited for agricultural production, carbon storage, provision of high-biodiversity habitats and biophysical climate regulation.[499] Putting in place a space climate observatory, an initiative supported by all European space agencies, as well as other states, including China, India, Mexico, Morocco, the Russian Federation and the United Arab Emirates, to guarantee free access to interoperable space-based Earth observation data will be a significant step forward in making available useful information for water, food and land supply through an Earth monitoring system.[500] Data collected using the social media platform Twitter can be used to cheaply determine real-time market prices for agricultural products.[501] And satellite imagery can be used to establish crop health, and, in connection with machine learning and drones, can build detailed weather models to help farmers maximize their yields while reducing their environmental impact.[502]

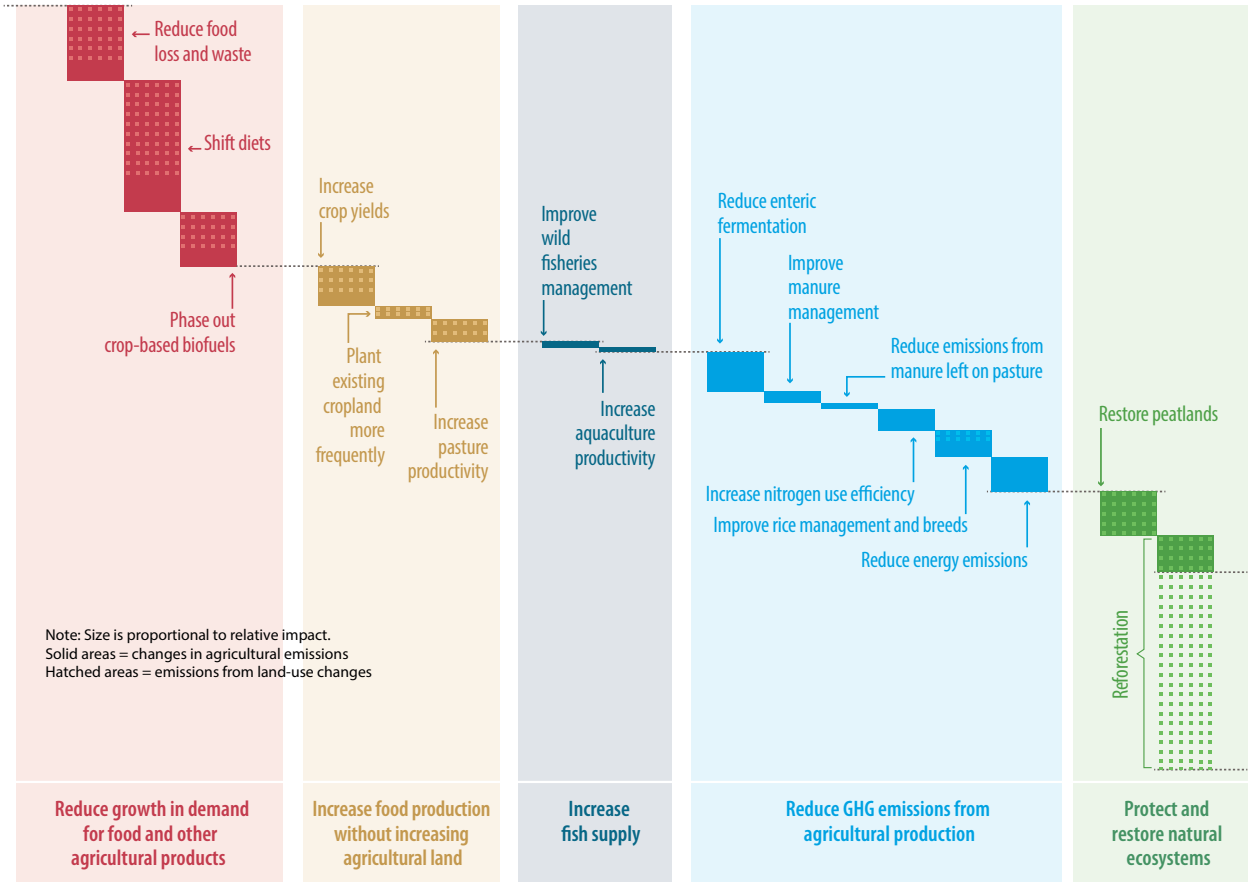
Infrastructure and transportation – Investments are needed in rural roads, electricity infrastructure, storage and cooling systems. Attention to infrastructure and transportation in the food system can be linked to efforts to shift energy and industry towards more sustainable practices and also to improve the accessibility and availability of nutritious foods, particularly for the most vulnerable, in hard-to-reach areas.

2.7.3. Integrated pathways to transformation

Societal development is to a very large degree based on accessing the Earth's natural resources. Access to those resources is, however, very unequally distributed within the global population. Leaving no one behind implies that access for many people to the development opportunities afforded by the Earth's natural resources must be increased. However, those resources are finite. At the same time, we can see from climate and other global changes that even the current human demand for natural resources potentially undermines the prospects for development to be based on accessing even more of those resources. The overarching theme, then, in the transformation required to bring the food system on to a sustainable trajectory is reducing its environmental impacts and ensuring that food systems are resilient to the effects of climate change. The actions of all four levers that can transform the food system vary from region to region, and there are clearly many

viable pathways. As prescribed in Goal 17, it will take a combination of tools, actors and solutions adapted to diverse contexts to achieve transformation of the food system.[503] Figure 2-10 shows an example of how various initiatives could be combined to feed 10 billion people with global food systems, resulting in a vastly reduced emission of greenhouse gases.[504]

Figure 2-10
Solutions to reduce agricultural emissions



There are doubtless myriad combinations of actions that can create pathways to sustainable global food systems. However, it is clear that the increase in the quantity and nutritional quality of the food needed to feed humanity in 2030 and beyond cannot be based on an increase in the total land area used for food production. Indeed, sustainable development in terms of biodiversity (Goal 15) may require a reduction in the total amount of land appropriated for food production, especially in light of the current focus on developing a bio-economy, in which biological resources are touted as potential substitutes for fossil fuels in other sectors, that is, energy and plastic production.[505] The biomass for those other societal uses also requires land area for its production. Technological developments, including industrial production forms and novel protein sources, are important contributors to reducing the area needed for food production. However, technology alone will not deliver the transformation needed.[506]

If the world is to feed an additional 2 billion people in 2050, food losses and waste will also have to be reduced. This means transforming the entire value chain from fields to households and requires new technologies in harvesting, transportation and storage (see box 2-22 on Nigeria's ColdHubs), as well as enhanced trade patterns and changes in consumer behaviour.[507] Improving the nutritional quality of the food produced and consumed also contributes to achieving the Sustainable Development Goals, both in terms of improving the general health of the population (Goals 3) and in order to increase the overall efficiency of food systems, thereby relieving pressure on environmental resources. Again, technology can play a role in improving nutritional quality by, for example, making new processing methods and products economically viable and available for consumers. However, dietary choices are also important. Meat consumption is the obvious case in point. In some parts of the world, people

eat meat only a few times per year, often in connection with ceremonies. In others, they eat meat several times per day. Meat production, especially when animals are grain-fed, which requires growing crops for feed, is particularly demanding in terms of environmental costs and, in many developed countries, a reduction in meat consumption would be accompanied by health benefits (Goal 3).[508]

Box 2-22
ColdHubs solar-powered storage in Nigeria[509]

Owing to limited infrastructure, it takes time for farmers to get their fruits, roots and vegetables on the market. When on the market, the sales price of the commodities fall quickly during the day as a cause of temperature and light conditions. A kilo of tomatoes can have lost between 25 and 50 per cent of its market value at noon compared with the price in the beginning of the morning.

At the end of the day, unsold commodities can be useless and farmers throw them out, which results not only in a lost profit for the small-scale farmers, but also sums up to a significant loss of food. Local estimates point to a loss of up to 25 per cent of annual income for the farmers. As soon as the perishable food is cut off from its source of water and nutrition, the deterioration begins and the commodities start losing weight, texture, flavour, nutritional value and consumer appeal.

To solve that dominant problem in many developing countries, the Nigerian start-up, ColdHubs, in cooperation with German researchers, has developed a simple solar-powered storage facility that works off-grid. Through a pay-as-you-store model, ColdHubs gives farmers the option to store their products in cool and sun-covered condition at a dozen local markets. The daily handling of the storage facilities is managed by local women, as the company experience is, that they can better be trusted with the flow of payments. In that way, the solution not only decreases loss of food and increases income for small-scale farmers, it also supports important livelihoods for women and their families.

Education (Goal 4) is a potentially important tool in supporting nutritional dietary choices. In 2012, for example, sustainability considerations were integrated into dietary guidelines in several Nordic countries. In Finland, where free lunches are offered to all school children, those dietary guidelines help shape consumption patterns from an early age. Cities and municipalities organize school food service as part of the curriculum, and they have put an emphasis on both increasing the amount of vegetables and vegetarian options available in schools and educating children on healthy and sustainable lifestyles. Those early interventions may have long-term transformational effects.[510]

Economic tools (pricing) that favour food products of high nutritional quality and low environmental impact are, however, also necessary to bring the practices that compose the global food system in line with achieving Agenda 2030. Sustainable diets should be made affordable, and unsustainable diets should be discouraged: a wise employment of taxation tools should align economic incentives with the health and environmental requirements of sustainable diets and discourage the consumption of ultra-processed food products that contain high amounts of sugar, salt and fat. Governments' food subsidies on staple foods can also support affordable, sustainable and nutritious diets.

For many people all over the world, however, better nutrition is not a question of choice, but rather of access. Today, over half the world's population lives in urban areas, and, by 2050, that proportion is expected to increase to nearly 70 per cent.[511] Municipal authorities of big cities can transform food systems by applying various drivers of change (see box 2-23 on Belo Horizonte).

Box 2-23
Belo Horizonte urban food policy[512]

In Belo Horizonte, Brazil, urban, integrative governance has been a major driver in eradicating hunger. In the beginning of the 1990s, 11 per cent of the city's 2.5 million inhabitants were living in poverty and every day 20 per cent of children were going hungry. Consistent with the right to an adequate standard of living, including food, the Municipal Secretariat for Food and Nutrition Security initiated a policy encompassing a range of approaches: subsidized food sales, school meal programmes, regulation of food markets, support for urban agriculture, establishment of a nutritional knowledge centre and development of educational food courses.

The integrative policy has contributed to a decline in extreme poverty rates from 17.2 per cent in 1991 to 5.6 per cent in 2010, while both infant and child mortality rates have more than halved in the same period of time.

The combined effect of the policy has relied on a systematic approach. Therefore, such a range of initiatives would not be possible if they were managed through traditional public governance silos. For example, the Secretariat would not have been able to serve school food if it not had been for the Department of Education, and the regulation of the food markets would not have been possible without the Agency for Urban Cleaning and Municipal Environment.

The experiences from Belo Horizonte has been that intersectoral work is not easy or straightforward. However, the longevity of the policy has depended not only on cooperation between governmental departments, but also on partnerships with private businesses and civil society organizations, as those have anchored the policy not with a single politician or party, but with local communities.

The discussion above concerning the environmental impacts of the food system focused on the amount of land dedicated to food production. Water is another global resource appropriated by the food system. Globally, approximately 70 per cent of the fresh water used annually is for the production of food.513 In regions experiencing permanent or periodic water shortages, the focus in drought situations is usually on the reduction of household water consumption. In most cases, however, restricting agricultural water consumption would potentially have a much greater impact on local water availability. Thus, in regions with limited water supply, agriculture often competes with human access to safely managed drinking water and sanitation services (Goal 6). The maximization of water-use efficiency in food production is therefore essential to achieving a sustainable global food system.

Food systems do not only directly use global resources in the form of land and water. They also release wastes in the form of nutrients, pesticides and antibiotics into the environment. The potential threats of poor management of pesticides to the environment are well recognized. However, there are also human health threats (Goal 3) generated by release of antibacterial and antifungal agents to the environment. Those agents can contribute to the development of human pathogens that are resistant to antibiotics.[514] Because animals get sick, antibiotics are often included in feed, and consumers' bodies gradually become less resistant to antibiotic treatment. Today, some 700,000 people die annually of drug-resistant infections. As use of antibiotics increases in low- and middle-income countries, health risks also rise related to food-processing biocides, such as disinfectants, food and feed preservatives or decontaminants.[515, 516]

Fertilizer use was also once regarded either as being relatively harmless to the environment, that is, contributing at most to local environmental degradation. However, global fertilizer nitrogen consumption increased by almost 100 teragrams of nitrogen per year between 1961 and 2013[517] and, if current practices continue, consumption is projected to increase by a further 70 to 100 per cent by 2050.[518] Globally, croplands account for over 60 per cent of nitrogen pollution.[519] Thus, the release of nutrients into the environment by agriculture is not only a local but also a global challenge.

The nitrogen contained in fertilizers influences the Sustainable Development Goals via a complex array of interactions that operate through climate, food production, and human and ecosystem health. In some cases, those interactions involve trade-offs, the most obvious being the need to increase nitrogen in degraded soils to meet Goal 2 while reducing nitrogen to support Goals 13 and others (Goals 6, 14 and 15). Working to achieve Goal 12 through sustainable

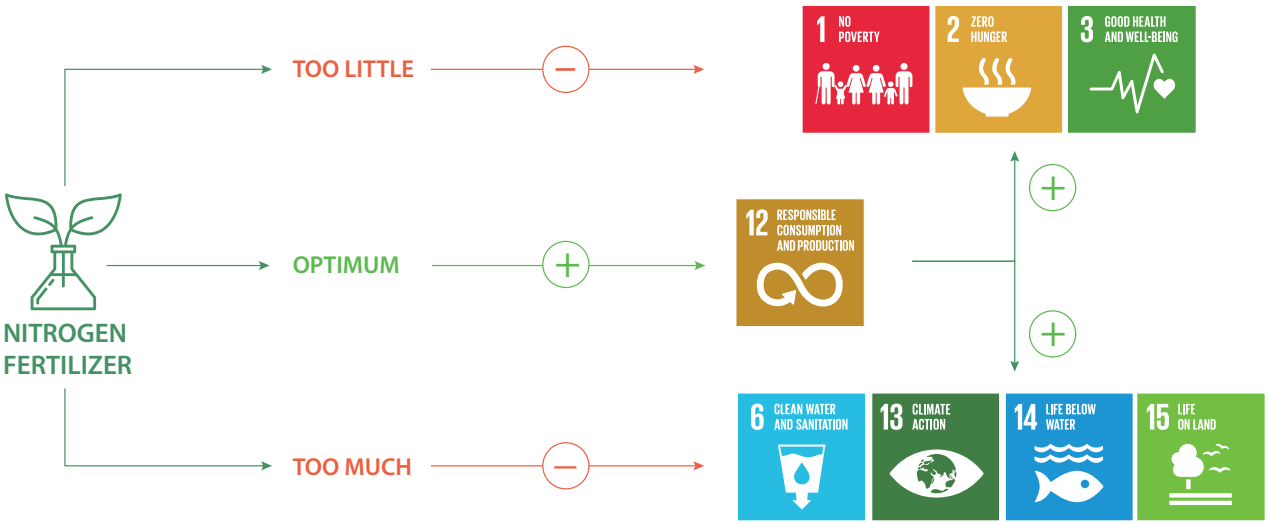
management will positively affect those Goals with targets related to too little or too much nitrogen use (see figure 2-11).

Too little nitrogen fertilizer results in low yields, soil nutrient mining and soil degradation, and subsequently poor human nutrition.[520] Where nitrogen use falls below optimum levels, improved access to nitrogen fertilizer is critical to ending poverty (Goal 1), hunger (Goal 2) and improving health and well-being (Goal 3). The flip side is that too much nitrogen fertilizer results in significant nitrogen losses both on and off farms, mainly through leaching and runoff, denitrification and volatilization, which contribute to groundwater contamination, eutrophication of freshwater and estuarine ecosystems, atmospheric pollution and soil acidification and degradation.[521] Nitrogen run-off and leaching are responsible for toxic aquatic algal blooms, which result in depleted oxygen levels, fish death and loss of biodiversity, which all undermine the realization of Goals 6, 14 and 15.[522] Nitrogen fertilizer is also responsible for more than 30 per cent of agricultural-related N_2O emissions, with the sector being the major source (approximately 60 per cent) of global N_2O emissions, which has potent greenhouse gas effects and thus has the potential to contribute to climate change (approximately 300 times greater than CO_2).[523]

The key to overall good nitrogen fertilizer management is balance, that is, applying sufficient nitrogen fertilizer to meet the demand for food while ensuring sustainability for future generations. Here, again, employing agroecological practices in farming and pursuing technological development, which can lead to precision delivery of fertilizers or eliminate the introduction of unused fertilizers to the open environment, will be key in developing sustainable fertilizer practices. However, governance (regulation), and economic tools (pricing) can also contribute to bringing current practices regarding fertilizer use to a sustainable trajectory. The Netherlands provides a good example of the effectiveness of well-targeted policies to implement best nitrogen-management practice; it has reduced fertilizer use to the same level as in the 1960s while doubling yields.[524]

Figure 2-11:
Impact of nitrogen fertilizer use

Impact of nitrogen fertilizer use on the achievement of related Sustainable Development Goals and situations in which too little, too much or optimal level of nitrogen



In some areas, for example, small island developing States and Arctic regions, where land and/or climate conditions are unsuitable for large-scale agricultural production, a significant percentage of human nutritional requirements has traditionally been derived from the harvest of ocean biota. While that continues to be the case, intense fishing and degraded coastal environments are threatening the continued exploitation of ocean resources by human societies.[525] Decreasing food security, in some small island developing States has led to an increasing recognition of the need to protect and restore local marine environments (Goals 14). [526]

As pressure increases on the use of land area for food production, there is an increasing focus on aquaculture and sea ranching, that is, food production either in localized marine facilities or release of cultured marine

organisms to supplement the potential for harvest from free-living marine populations.[527] Indeed, the increases recorded in marine harvests in recent years have been based on increases in aquaculture activities. Aquaculture currently accounts for approximately 50 per cent of fish consumed by humans.[528] Marine organisms are often of high nutritional quality (see box 2-24 on NutriFish), so there would seem to be tremendous potential for ocean harvesting to contribute to feeding humanity in the years to come. As in the case of conventional agriculture, however, aquaculture activities usually create negative environmental impacts. Thus, in order for aquaculture activities to contribute to a sustainable global food system, there must be a focus on minimizing its negative environmental impacts while maximizing the nutritional value of its produce.

Box 2-24
NutriFish in Bangladesh[529]

In Bangladesh, a collaboration between scientists, a private sector digital media company, broadcasters and the Government, produced a 60-second television spot to raise awareness among rural poor of the importance of eating traditional small fish. The NutriFish were chosen for their high concentration of certain micronutrients and vitamins, which are critical to the physical and cognitive development of children in their first 1,000 days of life. The initiative, which aims for behavioural change, was backed by new government policies to expand pond production of small fish. The World Bank has also encouraged new aquaculture solutions in its report on ending undernutrition in South Asia.

Already, we know enough to begin the transformation of the global food system to sustainable practices. However, a complete transformation of the food system requires new knowledge and new technologies. Thus, research has an important role to play in transforming the global food system. Scientists are already developing artificial meat either from plant protein or grown in the laboratory from animal tissues. Currently, culture of animal cells is very energy intensive,[530] so it is unclear whether such an approach has the potential to contribute substantially to sustainable development. Other technologies are farther along in their development, showing considerable promise to increase yields without increasing land use, that is, various forms of hydroculture, multi-storied greenhouses (vertical farming) and aquaculture.[531]

It is, however, not only technological research that can contribute to the development of sustainable food systems. Research on what constitutes healthy food is also necessary. Recent research, for instance, indicated that consumption of ultra-processed foods is associated with increased risk of cancers and hypertension.[532] Furthermore, diet is not only important for health, but also for the organisms that live in the human body. One emerging area of research concerns the role of diet and lifestyle in influencing human gut microbiota and the immune system.[533] That represents yet another interaction between Goal 2 and Goal 3 that may give rise to a new understanding of human nutritional needs and what types of diets actually best support human health.

The transformation of the global food system must, therefore, be carried out in a manner that allows the incorporation of our changing understanding of what constitutes healthy eating.

Progress in developing this understanding, as well as the technologies necessary to reduce the environmental impacts and increase the efficiency of the global food system, requires allocation of resources to research and development followed by active business involvement. The overarching goal for all actors involved in the transformation of the global food system must be to minimize environmental costs while at the same time maximizing the nutritional value of the products consumed.

Regional perspectives

While the Sustainable Development Goals are global, situations vary from region to region. Therefore, the global food system comprises many very different regional food systems. Access to the resources necessary for food production, especially water and fertile soil, also varies dramatically from region to region. That, of course, means that food security and reliance on imported food also vary regionally. Regions where resources are scarce are increasingly turning away from optimizing practices at the individual sector level and are instead bringing different sectors together to maximize their combined performance (see box 2-25).

Box 2-25

Water-food-energy-environment nexus in the Middle East and North Africa

In arid and semi-arid regions such as the Middle East and North Africa, there is focus on the water-food-energy-environment (including climate) nexus, where interlinkages between those four sectors are considered, that is, performance in the four sectors are considered together. Here, large amounts of agricultural land are lost annually owing to increases in salinity and land degradation.[534] In those countries, projects are carried out that focus on, for example, growing halophytes (salt-tolerant plants) such as quinoa and salicornia as bioenergy, feed and food crops; transitioning to agroecological systems in Morocco and Tunisia, via intercropping practices, crop rotations and cover crops useful in organic farming, which enable crop diversity, raise soil fertility, increase efficiency for nutrient uptake by plants, reduce pest pressures, manage erosion and enhance water absorption; shifting to conservation agriculture (in Morocco and Tunisia), which has socioeconomic, environmental and agronomic benefits (minimum tillage techniques that provide effective and natural solutions for soil and water conservation, increase organic matter content and carbon sequestration and therefore productivity while saving fuel, time, and labor);[535] using solar-powered irrigation systems by subsidizing the cost of solar pumping in Morocco and Tunisia,[536] coupling solar energy with desalination technologies in the Gulf Cooperation Council countries,[537] and recovering energy from wastewater treatment and reusing the biogas in wastewater treatment plants (Jordan and Tunisia).[538] Those examples show the potential and benefits that can be unlocked if technology and innovation are fully harnessed within such approaches.

Water resources are often shared over national boundaries, and interesting new governance mechanisms are evolving to manage those resources. One such example is the North-Western Sahara Aquifer System,[539] where Algeria, Tunisia and Libya established a consultative process at the technical level (in 2002) and political level (in 2007) to support sustainable shared groundwater resources management at the national and subregional levels. The project aims to strengthen transboundary water cooperation and institutional coordination among the countries participating in the System. Three main objectives are addressed: slowing down the depletion of groundwater resources and rationalizing water use, modernizing and increasing the value and viability of agriculture and providing sustainable energy for water management and economic development. Such initiatives, by which challenges in several sectors are addressed simultaneously while breaking down traditional silos, which are required to achieve the Sustainable Development Goals and propose effective policies.[540]

2.8 Entry point 4 – Energy decarbonization and universal access

Key messages

1. Energy poverty remains extensive, with 840 million people lacking access to electricity, predominantly in sub-Saharan Africa, and more than 3 billion people relying on polluting solid fuels for cooking, which causes an estimated 3.8 million premature deaths each year.[541, 542]

2. Continuing improvements in energy efficiency will be critical. Between 1965 and 2015, the world per capita energy consumption increased from 1.3 to 1.9 tons of oil equivalent, with average consumption being three to four times higher in developed countries, and the rate of growth of demand would have been even higher if not for the advances in energy efficiency during that period. Under a business as usual scenario, the demand for energy is expected to rise by 25 per cent in 2040, due to rising incomes and to a growing population particularly in the urban areas of developing countries, and again this increase could be significantly higher if not for continued improvements in energy efficiency.

3. Energy use for electricity generation, heat production and transport relies heavily on fossil fuels and together accounts for roughly 70 per cent of global greenhouse gas emissions.[543] Trends in energy-related greenhouse gas emission reductions are far from being on track to meet the Paris Agreement objectives. According to the Intergovernmental Panel on Climate Change, if current demand trends continue, renewables will need to supply 70 to 85 per cent of electricity in 2050 if we are to achieve the 1.5°C pathway, but the business-as-usual scenario sees renewables supplying only 22 per cent of the total energy in 2030, and a similar share in 2050. Overall, the rate of decarbonization needs to triple to reach the 2°C target and quintuple to reach the 1.5°C target.[544]

4. Cheaper renewable energy technologies, the rising role of electricity and digital applications are critical vectors for change in providing various energy services, and fossil fuels can be replaced through resilient, effective and context-specific energy mixes and with scaled-up efforts for energy efficiency and the promotion of renewables.

5. Transforming the transport sector across various modes (road, rail, air and maritime) is critical to achieving the goals of the 2030 Agenda and the Paris Agreement and require a combination of changes in both demand and supply: moving towards more public transport, mixed-mode and active mobility and towards new fuels, increased energy efficiency and sustainable electrification.[545]

6. Technological and policy obstacles remain. Slow progress in smart-grid management and long-term electricity storage, currently inadequate alternative energy sources for some transport modes; the lack of policies to ensure that biomass use does not reduce the free-standing biomass in nature; and the fact that when then social and environmental costs are factored in, direct and indirect governments' support to fossil fuels table 2-reaches 5 trillion dollars per year, while global public subsidies for renewables are in the range of 150 billion to 200 billion USD.[546]

Human survival and development depend on access to energy for heating homes, manufacturing goods and connecting across distances. In today's world, however, energy poverty remains extensive, with 840 million people without access to electricity, predominantly in sub-Saharan Africa, and more than 3 billion people relying on polluting solid fuels for cooking, causing an estimated 3.8 million premature deaths each year.[547] At the same time, humanity's heavy reliance on fossil fuels for meeting energy needs comes at an unacceptably high price for the climate and the environment. In particular, meeting the Sustainable Development Goals and the Paris Agreement targets for climate change depend on transformation and rapid decarbonization of our heating, electricity, industry and transport systems.[548] The challenge, then, is to give everyone the ability to meet their essential energy needs – to leave no one behind – and, at the same time, protect the climate and the environment.

Despite the adoption of the Paris Agreement and the 2030 Agenda in 2015, the global production of oil, coal and gas is still increasing to meet the growing demand for energy and infrastructure investments. This trend is completely incompatible with achieving most of the Sustainable Development Goals.[549] Unless the ambition level with respect to replacement of fossil fuel by non-fossil-fuel-based energy sources is massively increased, the energy-related global CO_2 emissions will continue to increase through to 2030 (see figure 2-13). As noted above, the Intergovernmental Panel on Climate Change has developed a number of scenarios for achieving the 1.5°C objective contained in the Paris Agreement, but even if the world is able to dramatically reduce its demand for energy by changing patterns in lifestyle, transport and diet, all countries will need to make swift and decisive moves towards renewable sources of energy.[550]

Figure 2-12:
Energy decarbonization with universal access

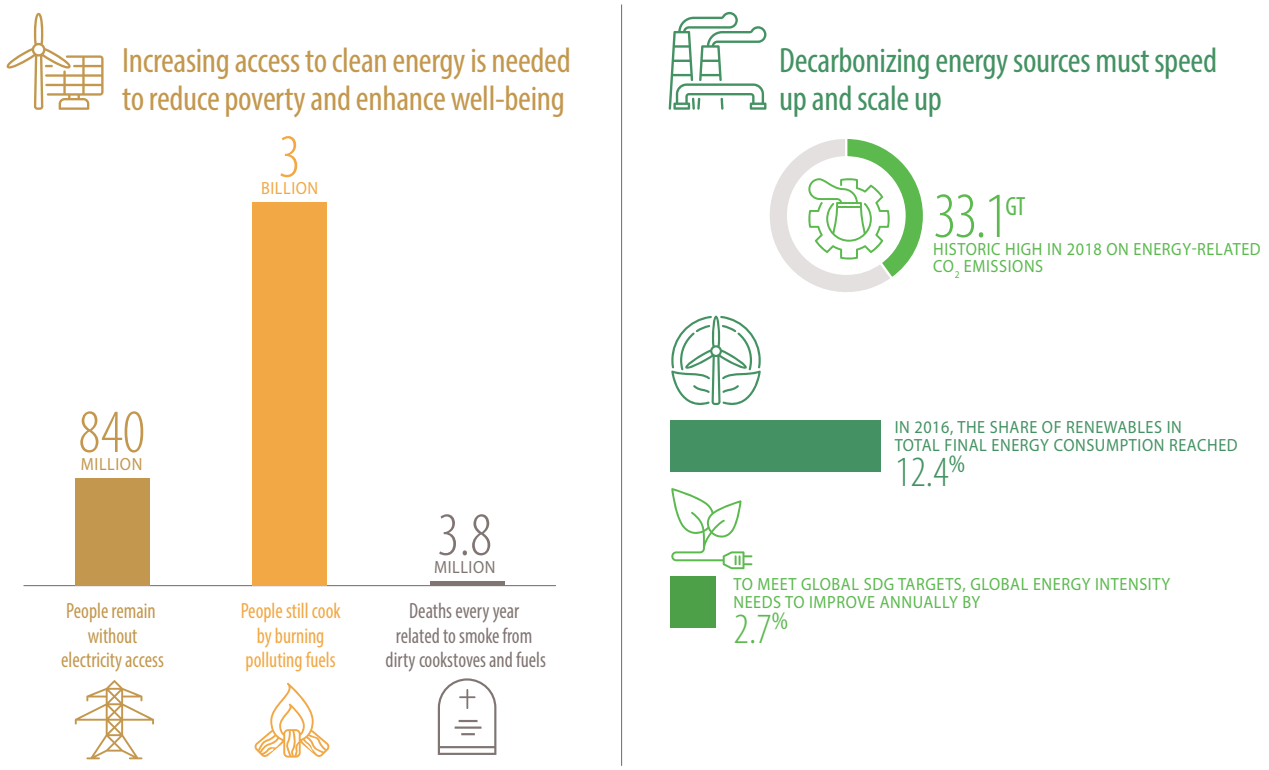
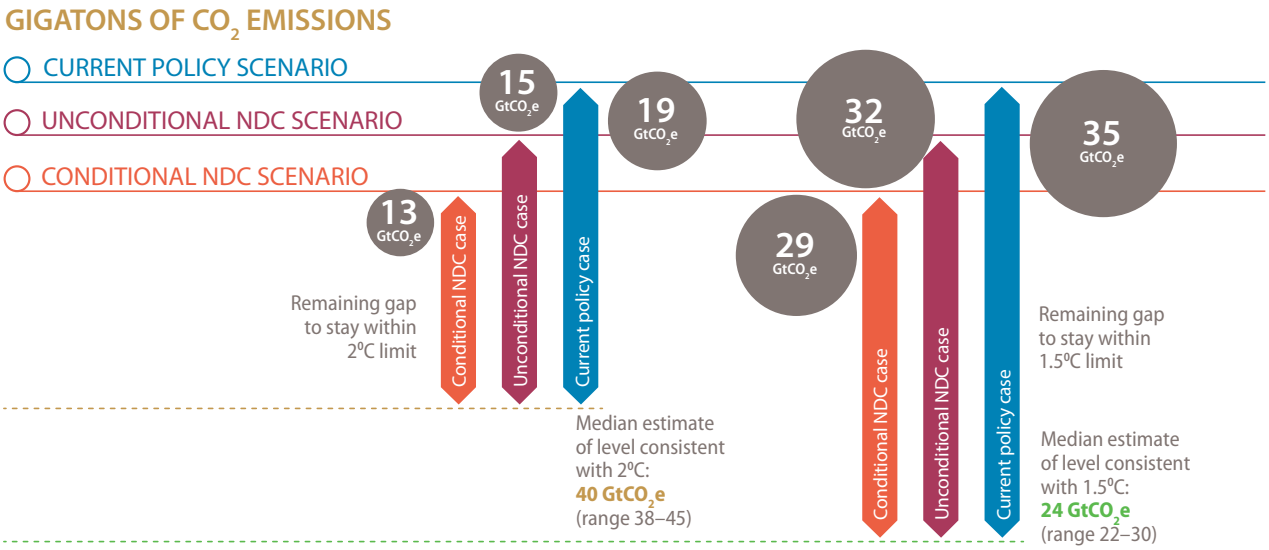


Figure 2-13:
The emissions gap: current commitments insufficient to achieve necessary reductions in emissions

Units are gigatons of CO_2 equivalent



Note : NDC scenarios are used to estimate what the total global GHG emissions would be in 2030 if countries fully implemented their pledged contributions. The unconditional NDC scenario assumes countries only implement mitigation-related actions of their NDCs that have no conditions attached. Under the conditional NDC scenario, it is assumed that countries implement both conditional and unconditional mitigation actions of their NDCs.

2.8.1. Impediments to progress

Supplying a world population in 2050 of an estimated 9 to 10 billion people with energy mainly provided by fossil fuel sources is simply incompatible with meeting global climate targets. Providing clean and efficient energy for all in a climate-friendly way is economically and socially desirable, and is technically feasible.[551] The benefits are predicted to outweigh the costs of transforming our energy systems by a factor of three.[552] It is estimated that for every dollar spent on shifting to a sustainable energy system, the transition would generate between $3 and $7, including through savings from reduced air pollution, improved health and lower environmental damage arising from the transition to clean energy sources.[553] Nevertheless, the energy transition will not accelerate by itself, and each individual segment of the energy sector (heat, electricity and transport) faces its own impediments with respect to its transition to sources friendly to the climate and the environment.

Strong lobbying for the status quo – Extraction and sale of fossil fuels has been a major contributor to economic growth since the Industrial Revolution. In 2017, 7 of the top 25 wealthiest global economic units (nation States and multinational companies) were industries based on fossil fuels (see table 2-1). It goes without saying that there are strong economic interests in continuing the fossil fuel dependence of the global energy system. Indeed, there is strong evidence of funding from the fossil fuel industry directed towards undermining the scientifically documented link between CO_2 emissions emanating from the use of fossil fuels and climate change.[554, 555]

Insufficient electricity storage capability – Under a business as usual scenario, rising incomes and a growing population are expected to push the demand for energy up, as high as 50 to 60 per cent by 2050.[556, 557] Some of that increased demand can be met by increases in energy efficiency. However, the replacement of fossil fuel by energy sources not based on fossil fuels is necessary in order to meet societal energy demand and, at the same time, achieve the Sustainable Development Goals. Many non–fossil fuel energy sources are intermittent in their delivery and cannot be accessed on demand, so the current lack of technologies for long-term electricity storage is an impediment to widespread reliance on non–fossil fuel energy sources.[558]

Negative emissions technologies not proven at scale – Shifting towards generating clean energy from sustainable sources is the main priority for mitigating the climate impact of the energy sector. However, in light of the urgency of the climate challenge and the long lifetimes of expensive energy infrastructure, the majority of modelled pathways towards the 1.5°C Paris Agreement target rely on negative emissions technologies. The amount of negative emissions is larger for those scenarios allowing for a temporary overshoot of 1.5°C warming limit above pre-industrial levels.[559, 560, 561] It is important to note that deploying negative emissions technologies at scale is unproven, and so relying on those technologies is quite uncertain in terms of their ability to limit climate change, and it is also a risk for food security and biodiversity.[562, 563]

Lack of alternatives to fossil fuels for transport – The transport sector accounts for 14 per cent of total global greenhouse gas emissions, and petroleum-based fuels currently supply 95 per cent of the energy used in the transport sector.[564] Shifts in consumer behaviour may reduce the demand for private transport dependent on fossil fuel energy, which is expected to reach its peak in the 2020s,[565] but the demand for heavy land transport, shipping and air transport continues to push overall fossil fuel–based transport on an unacceptable upward trajectory.[566] Improved access to airports and cheaper flights contribute to aviation being one of the fastest-growing sources of greenhouse gas emissions worldwide, and the projected growth of aviation is incompatible with the achievement of the Paris Agreement targets.[567] Eliminating the reliance on fossil fuels for transport – predominantly gasoline and diesel – requires radical institutional, technological and behavioural change. For road vehicles, shifting to electric power is critical to decarbonizing transport, though the impact[568] varies depending on type of electric vehicle, the source of energy generation, driving conditions, charging patterns and availability of charging infrastructure, governmental policies, and local climate in the region of use.[569, 570]

Skewed economic incentives – Direct government support for fossil fuel consumption in 2018 amounted to nearly $400 billion globally. Other estimates that factor in the social and environmental cost of the fossil fuel subsidies are much higher (on the order of $5 trillion).[571, 572] In comparison, the total impact of subsidies for renewable power generation are estimated at between $150 billion and $200 billion.[573] Moreover, the economic cost of using fossil fuel–based energy does not reflect the true cost to society in terms of pollution and health damage.[574] Estimates vary widely, depending on modelling assumptions, but climate scientists and economists think that the cost could be as high as $150 to $300 per ton of CO_2.[575] There have been some efforts to internalize the costs via carbon taxes, but those have been too few, covered only a few economic sectors and set at too low a value, often below $25 per ton of CO_2.[576]

Overreliance on biomass – In 2017, bioenergy accounted for roughly half the total global consumption of renewable energy, more than hydro, wind and solar

combined.[577] Biomass most often is used for producing heat, though biofuels are also an important substitute for fossil fuels in transport.[578] Although sometimes mistakenly referred to as being climate neutral, the burning of biomass does lead to the emission of CO_2, and biomass as an energy source can be considered as climate neutral, or a renewable energy source only when its use does not lead to a net reduction in global forest area or plant cover, in other words, when it does not reduce the function of the Earth's natural biological carbon sinks.[579] Burning biomass is also a major source of other air pollution, mostly indoors, which kills millions of people every year, and it must therefore be subjected to strict regulations and accompanied by increased access to clean cooking technologies whenever it is in use. That means that the availability of biomass that can sustainably be used in the energy system is finite and that there is a limit to the share of the global renewable energy supply that can be supported by biomass.[580] Biomass is a limited resource and should be prioritized for use in situations in which there is no obvious alternative, as its harvesting can lead to loss of biodiversity and trade-offs in terms of land rights, food security and access to water.[581]

2.8.2. Levers for transformation

Strategies for transforming the energy sector must maximize synergies and minimize trade-offs with other Sustainable Development Goals, including combatting climate change (Goal 13), achieving food security (Goal 2), reducing land use (Goal 15) and protecting freshwater sources (Goal 6).[582] This means using all of the available tools to advance the transformation to accessible and decarbonized energy. The potential for progress is clear, through a rapid scale-up of renewable energy; modernization of electricity transport, storage and distribution; and electrification of energy end uses.

Governance

The energy transformation requires long-term planning and well-designed policies by national governments and the private sector. Energy policies that include clear standards or targets are critical, as they help increase security for investors, reduce system costs and make clean energy more affordable. In 2018, specific targets for shares of renewables in heating and cooling were found in only 48 countries and in transport in 42 countries.[583, 584]

Governments can set policies mandating or incentivizing companies to make the necessary changes, for instance, to prepare mandatory decarbonization plans or participate in carbon-trading schemes. Policymakers should also assess and make clear the systemic risks to private investors of financing unsustainable thermal power plants that may soon end up as stranded assets.[585]

In designing energy policies, decision makers need to prioritize those at risk of being left behind, giving significant attention, for instance, to clean cooking solutions. Public acceptance depends on ensuring energy access for all and mitigating potential trade-offs with other Sustainable Development Goals.

Economy and finance

As agreed by world leaders in the Paris Agreement, global finance flows must be made consistent with low-carbon pathways while supporting the development and resilience of low- and middle-income countries. Fulfilling that objective depends in part on the political will to utilize the many promising available economic and financial instruments.

Governments can shape their spending and taxation policies to advance the energy transition by eliminating harmful fossil fuel subsidies and enshrining the "polluter pays" principle. As noted in box 2-16, there are successful examples of governments moving away from fossil fuel subsidies while ensuring that vulnerable populations do not suffer as a result. Carbon taxes and emissions trading are among the most cost-efficient policy instruments to reduce greenhouse gas emissions.[586] For carbon taxes to be most effective, policymakers should coordinate efforts internationally to avoid carbon leakage, by connecting existing trading systems and imposing tariffs for products imported from countries where no carbon control is being enforced.

Revenue from the above can be used to further accelerate the green transition and avoid negative effects of the energy policies on the poor.[587] Governments can invest in support to workers who lose livelihoods from the phasing out of fossil fuels and consider compensating income transfers for those at risk of losing energy access or increasing poverty during the shift away from subsidized fossil fuels. At the same time, it is important to note that the energy transition is resulting in net employment gains. In 2017 10.3 million people were employed in renewable energy, and that number is projected to potentially reach 24 million by 2030.[588]

People respond to price incentives, including off-peak metering and real-time pricing, to reduce the reliance on fossil fuel–based thermal power plants during peak hours. Efficiency standards and regulations have an essential role in reducing energy consumption at the consumer level, and labelling schemes for electric and electronic devices can also provide the information needed to make sustainable choices for the benefit of the planet, as well as for household economies.

In addition to those government incentives, the market itself offers incentives, as the price of some renewable energy sources has dropped markedly. In the past 10 years, costs of the generation of solar and wind energy have fallen by about 80 per cent, and 2018 marked the fourth consecutive year when over half of the added electricity generation capacity came from renewables, for the simple reason that wind and solar are now, in many cases, cheaper than fossil fuels.[589]

Individual and collective action

In addition to responding to policy and economic mandates and incentives, individuals and communities can make decisions based on their own principles, priorities and social and cultural preferences. Lifestyle choices made today—where and how to live and how to move around—and consumption patterns, especially in developed countries, can have a fundamental impact on the climate and energy systems of the future. Individuals, families and communities should demand greater energy efficiency and higher rates of renewables, as well as change current practices that rely on excessive energy use.

Education, advocacy and social mobilization are important tools in influencing energy-use practices both at home and with respect to transport.[590] Social and traditional media can amplify messages for change. The case of Greta Thunberg, the Swedish teenager who has inspired a worldwide youth movement for climate change action, shows the power of individual commitment communicated globally.

Science and technology

As noted above, many technologies already exist for increasing energy access and moving to decarbonized pathways, and those technologies are increasingly affordable.[591] Energy efficiency measures are simple and very effective ways to reduce fossil fuel demand and tackle air pollution, and energy saving technologies often lead to economic benefits in the long run.

At the same time, new and improved technologies are also needed, especially in smart-grid management and development, interconnection with neighboring regions, flexible generation, demand response, long-term and cost-effective energy and electricity storage, and energy sources for some transport modes. Research and development should support the necessary infrastructure for key technologies, including for heating and cooling networks, charging stations for electric vehicles and micro-grids for distributed energy generation. Power systems need to be designed to allow for high renewable energy penetration rates, and digital technologies can be deployed to improve the efficiency of distribution and availability of energy.[592]

For those new technologies and systems to come online, governments will need to design policies and incentives to encourage the necessary investments.

2.8.3. Integrated pathways to transformation

Access to energy and decarbonization are critical to achieving all the Sustainable Development Goals, securing human development, for example by fueling sustainable economic development (Goal 8) and improving livelihoods by reducing air, water and soil pollution (Goal 3), while also combatting climate change (Goal 13) and protecting our environment (Goal 14 and Goal 15). Providing access to clean energy also relates to gender equality (Goal 5) and health (Goal 3), in particular in the context of shifting away from biomass-based cooking, with its severe health consequences. Access to energy that can provide lighting can also contribute to improved educational opportunities (Goal 4), as it potentially allows students to study after sunset. To reap those multilayered benefits and make the energy transformation a reality, governments and local authorities need deploy the levers outlined above in an integrated and strategic manner.

Governments need to establish detailed plans of action to close the electricity access gap, backed by determined leadership, targeted policies and regulations, multi-stakeholder partnerships and increased investments in both on- and off-grid solutions. Government and businesses need to shift the focus from energy supply to the provision of energy services, such as lighting, heating, cooling and mobility, which can be delivered with a mix of energy and other solutions, for instance through building design, urban planning and the promotion of public transport and active mobility (walking and cycling).

The solutions need to be context specific, with energy mixes that include decentralized renewable energies that emerge from the disruptive changes in energy production and consumption.[593] Strategic investments by public and private sector entities, combined with smart policy and technology deployment, will help to shape the energy landscape in years to come (see example in box 2-26). Fossil fuel–based power generation without carbon capture and storage, as well as the internal combustion engine, need to be phased out by 2050. Given the long lifespan of energy infrastructure – for instance, the average coal plant built today, will be operational for at least 40 years – policy decisions made now will have an impact well into the middle of this century, when achieving the goals of the Paris Agreement implies a global society with net-zero greenhouse gas emission.

Box 2-26

Expanding solar lighting and sustainable electricity access in urban and rural Togo[594]

Togo has committed to expanding urban lighting and electricity access without increasing the country's carbon emissions through an extensive network of solar-powered street lamps. Since 2017, 10,000 solar street lamps have been installed throughout the five regions of Togo, including 1,000 lamps with five electrical outlets where consumers can charge household appliances and 1,000 lamps that combine charging outlets with Wi-Fi Internet hotspots. At the same time, the Government of Togo is well aware that the rural electrification rate lags far behind the urban rate and has therefore also initiated a programme to expand off-grid solar home electrification. The solar systems will be supplied by BBOXX of the United Kingdom, Soleva, a consortium of African-based Aphlion Energy and Wawa Energy Solutions. The Government of Togo will provide monthly vouchers to households to cover the cost of the solar power hardware. The International Finance Corporation is partnering with the Government in those efforts.

Governments also need to scale up investments in and commitment to energy efficiency across all sectors of the economy (see example in box 2-27), supported with evidence-based policies, including stringent building codes, responsible residential zoning, minimum energy performance standards, strict emission standards for light and heavy-duty vehicles, energy performance labels, cost-reflective energy tariffs and fuel economy requirements. Regional, national and local action plans with effective enforcement and monitoring will be critical.

Box 2-27

Holistic approach to promoting energy efficiency in Greece[595]

The European Union has set an energy efficiency target of 30 per cent savings by 2030. To move towards that goal, the Government of Greece has established an annual target for the energy efficiency of energy suppliers and users, notably oil suppliers, the transport and building sectors, and home and business owners. The Government has used various initiatives to help suppliers and consumers meet the target, including a public-private partnership by which 10 partner banks offer low- or no-interest loans to consumers for upgrading heating systems, insulation, and doors and windows in existing buildings. The National Fund for Entrepreneurship and Development partners with the banks in its In-house Saving II programme, and the Government is also partnering with the European Investment Bank and Germany to advance efficiency initiatives. Programmes found to be particularly promising by outside analysis include subsidizing upgrades to buildings that house small and medium enterprises and appointing energy managers and enacting comprehensive action plans in public-sector buildings. The Government of Greece predicts that its efforts will lead to an annual energy savings of nearly 1 billion kW.

As noted above, transport poses particularly difficult challenges to the energy transition. The potential transformation pathway for heavy transport – aviation, shipping and long-distance heavy-vehicles – involves the use of biofuels, at least as an intermediate step.

There is an upper limit to the amount of biomass that can be appropriated for human purposes without diminishing the natural environment's capacity to take up and store CO_2 from the atmosphere through photosynthesis. Use of biomass potentially interacts with Goal 14 and Goal 15 (life under water and on land) and Goal 2 (zero hunger), as there may be competition between land appropriated to food and energy crop production. Given the limited availability of climate-friendly biomass, it would seem appropriate to prioritize its use to cases where there are no obvious alternatives. Some forms of heavy transport, for example, aviation, may be potential candidates for such prioritization, as there currently do not appear to be viable alternatives to decarbonize.

The energy landscape is shaped by national and regional contexts, and in some cases, nuclear energy is a part of the energy mix (see box 2-28.)

Box 2-28
Nuclear energy[596]

There were approximately 450 nuclear power reactors in the world in 2018, producing about 11 per cent of the total electricity. For each kWh of electricity produced, a life-cycle assessment shows that nuclear plants emit 4 to 110 grams of equivalent CO_2, with a median value of 13.[597] That is similar to the life-cycle assessment emissions of wind and photovoltaic energy, and much lower than for electricity generated by coal (typically 800 grams) or gas (about 400 grams). If the electricity now produced by nuclear plants was based on gas or coal instead, world CO_2 equivalent emissions would be higher by approximately 1 or 2 gigatons of CO_2 equivalent emissions per year.

In 2018, the average age of nuclear plants was 30 years, and it continues to increase, as relatively few new plants are built. After the Chernobyl and Fukushima accidents, and owing to safety concerns after the terrorist attacks of 9/11, the safety requirements have been reinforced, and the building costs have significantly increased. The levelized cost per MWh produced by a nuclear plant was estimated by the Panel's Working Group III (2014) at approximately $100 in 2012, compared with $70 for gas (see Annex II of Fifth Assessment Report of Working Group III of the Intergovernmental Panel on Climate Change). In 2012, the estimate was $80 for onshore wind, and 220 for rooftop solar photovoltaic. The International Renewable Energy Agency estimates $60 and $50, respectively, for 2018.

Even though there are limits to the use of levelized costs for comparing the competitiveness of energy supply technologies, the observed trends suggest renewable energy will soon be increasingly more competitive than nuclear energy. The economics of new nuclear plants is heavily influenced by their large capital costs, and those have had a tendency to increase for safety reasons. That means that few private investors are willing to invest in them. Adding to the difficulties is the fact that the safety of long-term management of nuclear waste is still an unresolved issue, public concerns about nuclear safety have not disappeared and only a small fraction of the risk of accidents is covered by insurance companies, the rest being assumed by governments.

As a conclusion, existing nuclear power plants have avoided the emission of greenhouse gases, and their decommissioning should take place only after careful planning, so that they are not replaced by new fossil fuel power plants. Building new plants seems to be increasingly harder to justify, given the costs involved, and the decreasing costs of renewables and storage capacities.

Any successful transformation pathway likewise needs to be shaped by its regional and national context. In low-income countries in Africa and Asia, for instance, the emphasis will be on increasing access, and for at least 50 per cent of the future connections in sub-Saharan African, off-grid solar systems will be the most cost-effective solution. In the Arab region, 94.5 per cent of households have access to electricity, but uptake of renewables is a severe challenge. While the Latin American region generates 27.6 per cent of its total final energy consumption from renewables, the rate of energy efficiency and renewable use is not rising fast enough in OECD countries to meet the targets in the Paris Agreement. And a stark figure reminds us that 2030 Agenda will fail if we allow people to be left behind: 90 per cent of the over 65 million people worldwide who have been forcibly displaced from their homes are living without access to electricity.[598] The gender dimensions of energy transitions are often overlooked but are important (see box 2-29).

Box 2-29

Intersection of gender, health and energy in Indonesia: clean cooking initiatives and fiscal sustainability[599]

Household air pollution from biomass fuels is a significant challenge in Indonesia and was responsible for 60,835 deaths (4 per cent of all deaths) and 33.7 million lost disability-adjusted life years across the country in 2016. The Indonesia Clean Stove Initiative, a partnership among the Indonesian government, Indonesian civil society organizations and private sector companies, and the World Bank, aims to expand the use of clean cooking technology, targeting communities currently cooking with biomass fuels. The programme now focuses on the Central Java and Yogyakarta regions, and the World Bank has used results-based financing approaches to provide incentives to 10 private sector suppliers who have distributed clean cookstoves in those regions. Initial results find that the efforts to disseminate the clean cookstoves—whether based on liquid petroleum gas or new, safer versions of wood-burning stoves—are most effective when paired with community-based training and awareness-raising campaigns. Success will be particularly significant for women, the primary users of the stoves, both in terms of their health outcomes and improved quality of life as they are freed from firewood collection and other related duties. As part of the overall strategy to improve energy access and address health concerns, the Government of Indonesia is also shifting subsidies from kerosene to liquid petroleum gas. As a result, consumption of liquid petroleum gas in final energy mix grew from 1.7 per cent in 2006 to 8 per cent in 2015. The Government is now working to ensure that the subsidies reach the low-income households that need them most.

When national and regional energy policies are developed, a thorough assessment on expected impacts on the Goals in other parts of the world should be carried out. The concept of telecoupling—understanding how human and natural systems are linked over long distances—can help in such analysis. A recent study applying this concept to European Union energy policy showed that although European policy for promotion of renewable energy sources is regionally ambitious, it also has major impacts beyond the region, on biodiversity and the Goals.[600]

2.9 Entry point 5 – Urban and peri-urban development

Key Messages

1. Sustainable cities are central to achieving all 17 Sustainable Development Goals, because if current trends continue, by 2050 cities will contain approximately 70 per cent of the world's population and produce 85 per cent of global economic output. Policy and investment decisions made today will have a deep and long-lasting impact, based on the concentration of people and economic activities, and the "locked in," long-term nature of urban systems and infrastructure.

2. Urban development should proceed in a well-planned, integrated and inclusive manner, with city governments working together with businesses, civil society organizations, academia and individuals, and also with national governments, as well as the authorities in neighbouring peri-urban towns and rural areas, and peer cities around the world. A robust "science of cities" can give urban policymakers around the world access to a body of knowledge and good practices.

3. Urban and peri-urban decision makers should take the central tenet of the 2030 Agenda to heart and ensure that no one is left behind in their cities and towns. That means prioritizing pro-poor development and access to decent jobs; high-quality public services, health care and education; sustainable transport; and safe and attractive public spaces for all, regardless of gender, age, ability and ethnicity.

4. Governments, businesses, civil society organizations and individuals can use a range of policy, economic and communications tools to promote sustainable consumption and production patterns in cities, encourage densified habitat and decouple growth from environmental degradation.

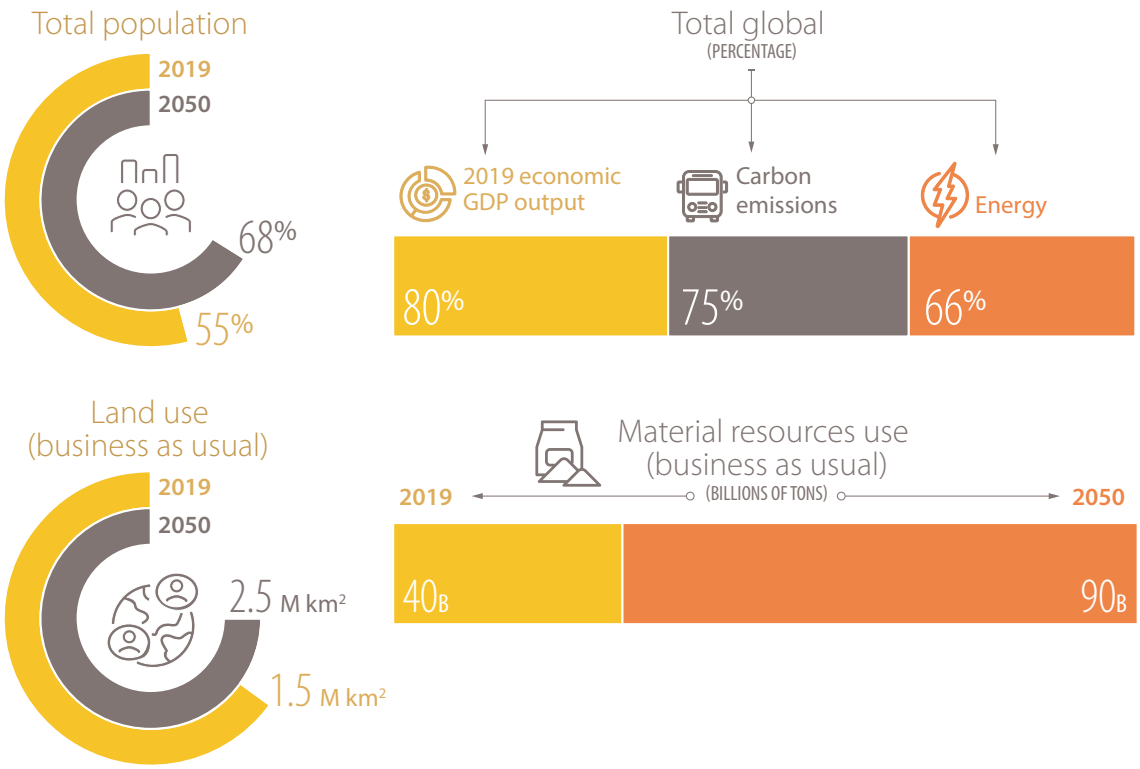
5. Innovative governments, a committed private sector and an active citizenry can overcome inequalities and create liveable cities in both developing and developed countries. Liveable cities offer high-quality services and increased "naturbanity", a close connection between people and nature, to enhance human health and well-being, protect biodiversity, and strengthen climate resilience, which is particularly important for vulnerable populations in coastal cities and those in informal settlements.

2.9.1. Impediments

Any successful path to achieving the 2030 Agenda will run through sustainable cities.[601] At current rates of growth, by 2030, 60 per cent of the world's population —close to 5 billion people—will live in cities, and by 2050 that proportion will be nearly 70 per cent.[602] By 2050, if trends continue, as many as 3 billion urban dwellers will live in informal settlements, or slums.[603] That same year, cities will produce 85 per cent of global economic output.[604, 605] Projections show that 1 billion urban residents will be living in low-elevation coastal zones and are therefore at risk of flooding and natural hazards related to climate change. If current trends continue, at least 15 per cent of the new urban population added between now and then will be living with some kind of disability.[606, 607]

The challenges are vast and multifaceted. Urban policy decisions have extraordinarily far-reaching impacts in poverty alleviation and reduction of inequalities, and in ensuring access to energy, transportation, waste management, food supply, water and sanitation, education, health care and others, not just for urban populations but also for the surrounding peri-urban and rural areas (figure 2-14).

Figure 2-14
Urban and peri-urban development: growing cities, growing impacts



Cities can create opportunities for employment, poverty alleviation and growth, and they are hubs of research and development, with concentrations of academic, scientific and private sector institutions that drive innovation. The sheer number of people living in cities means that there is the potential for efficiency and large-scale progress. On the other hand, there is also the risk of locking in unsustainable infrastructure and urban designs that will affect large populations for generations to come. Buildings constructed now – as well as urban systems like water, transport, energy, and others – need to contribute to carbon-neutral cities if the world is to achieve the targets contained in the Paris Agreement.

Inequality

Cities are not immune to the severe income disparities and extreme inequalities that plague the world at large. There is often a wide income gulf between rich and poor, sometimes even within the radius of a few miles and between well-established residents and the recent migrants and urban poor who provide low-cost services. In addition, urban areas are often supported by surrounding peri-urban and rural areas that suffer from high rates of poverty.[608, 609, 610] In sub-Saharan Africa, 47 per cent of the urban population currently lives in slums.[611] And the vulnerability of people living in informal settlements, often in exposed areas with inadequate infrastructure and low-quality housing, is exacerbated by climate change and the associated rising sea levels, flooding, landslides, heat stress, water scarcity and other threats.[612] Persons with disabilities face difficult barriers to an active life in many cities around the world when the public transport, public buildings and commercial centres are not made accessible to them.[613]

Pollution

Around 90 per cent of people living in cities breathe air that fails to meet WHO standards (10 micrograms of particulate matter per cubic metre), and in low- and middle-income countries 97 per cent of cities with more than 100,000 people fail to meet the standards.[614]

Cities are also producing solid waste at increasing rates, and in 2016, cities produced 2 billion tons of solid waste. The rates are projected to continue to rise, and, unless trends change, by 2050 the solid waste generated annually will increase by 70 per cent.[615] Globally, only 65 per cent of the urban population has access to municipal waste management.

Urban sprawl and resource use

In the developing world the land occupied by cities will triple by 2050, signalling a move towards the sprawl that already characterizes cities in developed countries.[616] In many cases, that urbanization is proceeding organically, without planning, and with urban centres concentrating in coastal areas, residents live with a high risk of flooding, mudslides and other disasters.[617, 618]

If development continues in the business-as-usual model, by 2050 the cities of the world will consume 90 billion tons per year of raw materials such as sand, gravel, iron ore, coal and wood.[619] Urban growth often involves destroying natural habitats and green space, with the resulting loss of biodiversity. Even accommodating more people in high-rise housing increases environmental and infrastructure stress, and recent studies show that low-rise, high-density housing may be more effective and sustainable.[620,621] And while cities cover only 2 per cent of the Earth's surface, their "water footprint"—the area covered by the sources of their water—accounts for 41 per cent of the Earth's land surface.[622]

Greenhouse gas emissions and climate change

Cities are responsible for 70 per cent of the global greenhouse gas emissions from burning fossil fuels. In some cases, particularly in developing countries that are rapidly urbanizing, with the associated rise in income, city dwellers contribute more to greenhouse gas emissions per capita than their rural counterparts. Developing world and developed world cities contribute similar levels of greenhouse gas per capita, while rural dwellers in developing countries contribute much lower levels.[623] On the contrary, in developed countries, urbanites often contribute much lower levels of CO_2 than rural inhabitants in the same country.[624]

In addition, cities have elevated temperatures compared with rural areas, a phenomenon known as the "urban heat island".[625] In a recent systematic review of scientific articles from January 2000 to May 2016, urban growth was found to have a large impact on local temperatures, in some cases by up to 5ºC, and climate change exacerbated the impact.[626] Higher temperatures increase the risk of heat-related mortality.[627]

2.9.2. Levers for transformation

A 2030 Agenda city will be a liveable city with a flourishing economic base with decent jobs for all and a compact footprint with mixed land use, including residential, commercial, educational and green public spaces. That city will leave no one behind and will be accessible to all, including women, youth, persons

with disabilities and other vulnerable populations.[628] Decision makers in the public and private sectors will move their cities towards achieving the 2030 Agenda using the levers of transformation for urban planning and land use, high-quality infrastructure and public services, transport systems and digital connectivity, as well as inclusive and participatory decision-making.

Governance

Sustainable cities will not arise organically, or by allowing business to proceed as usual or according to the directives of the market. Rather, urban development should proceed in a well-planned, evidence-based, integrated and inclusive manner, with city governments working together with businesses, civil society organizations, and individuals, and also with national governments, and the authorities in neighbouring peri-urban towns and rural areas. In addition, city governments can learn from, and act in concert with, peer cities within their countries and around the world to increase the impact of their policies.[629]

Successful urban governance is inclusive and participatory, taking into account the priorities and values of all stakeholders and reflecting the unique character and history of a city's community. Promoting active decentralization or subsidiarity – devolving responsibility to the lowest or least centralized level of governance that makes sense – is important for effective policymaking, service provision and budgeting. Today, scholars recognize that there are many models of cities – that is, various "urban fabrics" shaped in part by the ways their citizens live and move around, whether by walking, transit or automobile – and that the policymakers and other stakeholders closest to the ground are often best equipped to plan for a city's future.[630]

Effective urban, peri-urban and rural governance also serves to secure land and property rights, a critical issue, as currently less than 30 per cent of the global population has documentary land rights. Studies show that people and the private sector invest more in land when they feel secure about access to land. Individual and collective land rights are important for the improved resilience of indigenous peoples, women and other vulnerable groups. [631]

Economy and finance

Integrally tied to questions of governance are the policy and business decisions that direct economic activity, build infrastructure, provide services, and drive innovation in urban areas and their surroundings. Massive infrastructure investment is needed over the coming decades, and investment decisions made now will shape the sustainability of the urban landscape for decades to come. The world needs more than $40 trillion in new and upgraded infrastructure between 2005 and 2030, and much of this investment will be directed to cities in developing countries.[632] The African Development Bank estimates that the African continent needs $130 billion to $170 billion per year in infrastructure investment, with a current funding gap of $68 billion to $108 billion annually.[633] Those investments, in buildings, transport, information and communication technology will spur economic growth and job creation, as well as enhance the quality of life for urban citizens.[634]

The Climate Economy Report by the Global Commission on the Economy and Climate found that more compact and connected urban development, built around mass public transport, can create cities that are more economically dynamic and healthier and that have lower emissions, and could reduce urban infrastructure capital requirements by more than $3 trillion over the next 15 years.[635]

The economic activity of cities needs to revolve around pro-poor development and access to decent jobs for all, with special attention to access for women, youth, persons with disabilities and other vulnerable groups. Government and the private sector need to invest in sustainable and technology-enabled industries and livelihoods that will help decouple growth from environmental damage.

Individual and collective action

In a city the degradation of the environmental commons is not an abstract phenomenon. People see it in the loss of green space and sense it in the polluted air. Left-behind populations live and struggle in slums sometimes a few feet away from wealthy communities and bustling commercial districts. Refugee tensions are a risk, as migrants escaping conflict and desperate situations seek opportunities in urban areas, placing strain on the resources and infrastructure of the host cities. And when cities are not equipped to absorb the newcomers, the resulting rootlessness and anomie within the migrating populations can undermine their social development.[636]

But with an appreciation of the problems can come a communal spirit and a commitment to action. The unavoidable reality of environmental strain, pollution and waste challenges, for instance, can spur citizen campaigns and social engagement. Many will follow initial first adopters, especially because the population of urban settings often skews younger, better educated and more environmentally conscious. City dwellers learn by observing and building on one another,

breaking from old, unsustainable lifestyle choices and pioneering new behaviours.

Science and technology

Cities are hubs of innovation and creativity, with their concentration of universities and research institutions, large commercial centres, infrastructure and multiple outlets for social and cultural exchange. The trends are self-reinforcing, as highly educated individuals from rural and suburban areas are drawn to relocate to well-resourced cities, seeking professional opportunities and social and cultural enrichment. Recent studies have found that multinational corporations are investing the bulk of their research and development funds in institutions based in global cities in developed and developing countries and establishing their regional headquarters in those same urban areas.[637]

In developed and developing countries, technology is changing the way people live, with communication and digital connectivity making it possible for people work and interact online without leaving their homes. Commerce in particular has been transformed, and online shopping for everything from groceries to medical prescriptions will continue to grow in a steep upward trend in all regions in the world, according to a recent study, with most of the growth occurring in densely populated urban areas.[638] Policymakers and other stakeholders need to plan in a nimble and responsive way to take full advantage of the role that technology will play in the development of sustainable cities. In some cases, that means acknowledging that some of the value added of cities – the economies of scale in providing services – will become less significant as technology enables remote and virtual service provision. For those countries – notably small island developing States and landlocked developing countries – that are far away from global market centres, the new emphasis on e-commerce is requiring significant investment in logistics and transport services.[639] Since 2016, the United Nations Conference on Trade and Development (UNCTAD) has conducted 17 Rapid eTrade Readiness Assessments to help least developed countries identify barriers to take advantage from e-commerce and the digital economy development. They underline the significant need for more assistance to those countries to ensure more inclusive outcomes from digitalization.[640]

Smart cities, where technology is leveraged to improve the lives of urban citizens and help municipal governments provide services more effectively, are growing in all regions of the world. With access to a wealth of data, city planners and policymakers can cut down on traffic congestion and accidents, increase nature-based solutions to adapt for climate change, address pollution and other health and safety risks, reduce CO_2 emissions, take into account the logistical needs of a circular economy and design commercial areas that better meet the needs of consumers and business owners.[641, 642]

In addition to the science and innovation emerging from cities, effective urban development also benefits from a robust and comprehensive science about cities. Cities can learn from each other, and it is important that local and national governments, universities, research institutions, civil society organizations and businesses support a strengthened transdisciplinary, multifaceted urban science. The "science of cities" can be bolstered by investing in education and training of well-qualified urban planners and other professionals ready to address the multiple challenges of urbanization. An expert panel convened by *Nature Sustainability* found that cities of all sizes and locations would benefit from enhanced science-policy connections at the city level that bring together experts from all relevant disciplines. The panel called for cross-regional collaboration, the development of urban observatories, and a strengthened link between multilateral organizations and cities.[643]

2.9.3. Integrated pathways to transformation

To be effective and sustainable, interventions in governance, economy, behaviour and technology should happen in an integrated and mutually reinforcing manner, with the municipal government holding the reins and working in close partnership with the national government, private business, academia, civil society, citizen groups and international organizations.

Governments and their partners will work towards creating liveable cities, where people live free from

poverty, free from the burden of inequality, including gender inequality, and free to pursue decent livelihoods with a guarantee of the essential social services needed to ensure the well-being of each citizen.[644,645] Creating a liveable city means strengthening climate resilience and addressing air pollution, especially for vulnerable populations in coastal cities and other urban and peri-urban areas. A liveable city is also one fulfils the less tangible needs of its citizens, the need for connection to the heritage and character of a place, the need for links to nature and the surrounding peri-urban and rural areas that provide so many of the resources and services that enable urban life and the need for community cohesion and social ties.[646]

As they move along the transformation pathway to liveable cities, governments and their partners must work towards fully decoupling growth from environmental degradation and also from the inequality that plagues so many cities today. Urban decision makers should take the central tenet of the 2030 Agenda to heart and ensure that no one is left behind in their cities and towns. That means prioritizing pro-poor development and access to decent jobs, effective public services, quality health care, education, safe drinking water and sanitation services, nutritious food, reliable transportation, and safe and attractive public spaces for all regardless of gender, age, ability and ethnicity.[647] Urban planning should be carried out in an inclusive manner, with particular attention paid to the needs of those living in informal settlements, refugees and persons with disabilities.[648] The nature of urban planning will vary according to the size and circumstances of individual cities, with secondary cities facing challenges related to their relative lack of resources (see box 2-30).

Box 2-30

Future city growth

By 2030, the world is projected to have 43 megacities (i.e., cities with more than 10 million people). Nine of the 10 new megacities that will be added between now and then will be in the developing world.[649] However, the majority of urban dwellers of the future will not live in well-resourced mega cities but rather in secondary cities and other areas without well-defined boundaries and without adequate infrastructure. While around one in eight live in 33 megacities, nearly half of the world's urban dwellers reside in settlements with fewer than 500,000 inhabitants or secondary cities.[650] Although, generally, larger cities are more well-resourced and economically powerful than their smaller counterparts, recent studies have shown that size is not destiny. A World Bank report on competitive cities found that a number of secondary cities were beating many larger cities in terms of job growth, productivity and foreign direct investment. Those include Saltillo, Mexico; Meknes and Tangier, Morocco; Coimbatore, India; Gaziantep, Turkey; Bucaramanga, Colombia; Onitsha, Nigeria; and Changsha, China.[651, 652]

There are regional variations. In developed countries, local governments, businesses, civil society organizations, and individuals can use a range of policy, economic and communications tools to promote sustainable consumption and production patterns. Well-planned land use, effective urban public transport systems including active mobility (walking and biking), rapid scale-up of renewable energy and energy efficiency, and promotion of sustainable and technology-enabled businesses and jobs will all be important. Eliminating poverty in all its dimensions remains a top priority in developing countries, and decision makers in the Global South will also seek opportunities to follow a new, transformed development path that avoids the "grow now and clean up later" approach that characterized so much of the North's urban development.

Infrastructure and planning for resilience

Infrastructure offers an illustrative case. As noted above, massive amounts of infrastructure investment will be needed in the coming years to achieve the Sustainable Development Goals. While retrofitting the "grey" infrastructure of the West is critical, in the developing world there are opportunities to "leapfrog" the older resource-intensive approaches to infrastructure into tech-enabled, green and sustainable choices.[653, 654] The Intergovernmental Panel on Climate Change found that as secondary cities in developing countries develop, they have particularly promising opportunities to follow sustainable pathways, through investments in infrastructure and urban design to advance climate change mitigation, social inclusion and liveability (see box 2-31).[655] Accessibility to all, regardless of age or ability, adhering to the principle of universal design, should be a priority in all infrastructure planning.[656]

Box 2-31

Urban development opportunities in landlocked developing countries[657]

Landlocked developing countries experience a number of vulnerabilities, many of which stem from their distance from major global market centres and from ocean-based trade routes. International investment in landlocked developing countries has traditionally been relatively low, and infrastructure development in cities in landlocked developing countries as a result has often lagged behind many other cities of comparable size and population.658 That has created obstacles to growth and advancement landlocked developing countries over the years, giving them and their partners added incentives to work to avoid the "grey" infrastructure based on fossil fuels and automobiles that characterizes many more developed cities.

In Rwanda, government and business leaders have collaborated to build capital city Kigali into a smart and liveable city. The government has launched the Irembo Platform so that citizens can access public records, request birth certificates and schedule driver's licence tests online. In partnership with global technology companies Nokia and SRG, the city is deploying advanced sensors to aid in waste and utility management. Solar lamps and effective public transport systems are making the city safer and more accessible to residents while keeping air pollution and the carbon footprint in check. At the same time, links – at least virtual links – are being strengthened between rural and urban areas in Rwanda as broadband coverage expands into the hinterland, thanks in part to a partnership between the government and the International Telecommunications Union. That connectivity, together with the increasing use of digital health records and tele-medicine functions, is shrinking the gap between urban and rural quality of life. Challenges remain, of course, including the fact that for a majority of the city's population, the home prices in some of the new neighbourhoods are far out of reach. Still, the development of Kigali illustrates the potential for cities that start with underdeveloped infrastructure and services to leapfrog into an era of efficient tech-enabled services and higher quality of life.

In addition, the geographical location itself of landlocked countries, which has long posed hardships to the cities in them, may also provide opportunities. Cities in Mongolia and Lao People's Democratic Republic, for instance, are attracting infrastructure investment from China and other partners because of their strategic location along the Belt and Road Initiative route. As important transit countries, these landlocked developing states can make a strong case for meaningful investment in sustainable transportation infrastructure within and between their major cities.

Governments need to deploy the various levers discussed above in an integrated and strategic manner if there are to make effective decisions on infrastructure investment and urban planning. National governments can support sustainable urban development not only by allowing the decentralization of responsibilities to guide governance structures, but also by investing in small and secondary cities, and encouraging polycentric modes of development, in which people live and work in mixed-use hubs connected by effective and accessible public transport.[659, 660] Governments also need to invest in innovative approaches to building and manufacturing to advance economic development and expansion of livelihood opportunities while working towards the 2030 Agenda as a whole.

With infrastructure's high price, long lifespan and direct impact on citizens' lives, municipal governments need to enter into a variety of partnerships when embarking on those projects. Inclusive and participatory planning is critical, and it is particularly critical to ensure that vulnerable populations have a seat at the table. Fostering the use of local materials could provide an economical and resilient alternative to the use of standard building materials.

The private sector can be a key partner in sustainable projects, and governments can use tax and other positive incentives to motivate business engagement.[661, 662] It is imperative, though, that city governments enter into partnerships with the private sector with clear parameters and a determination to form smart, mutually beneficial collaborations, ensuring that the needs of their citizens come first. Blended finance is not a panacea, particularly in low-income countries, which may not be able to provide private companies with the assurances of profit with the relatively short timelines on which they are used to operating.[663] With that in mind, donor countries and development banks and other finance institutions should maintain a high level of commitment to funding urban infrastructure projects in the developing world.

Broadly speaking, economic tools to advance sustainable development in partnership with the private sector need to revolve around the concept of accurately pricing negative externalities in addition to positive benefits. For instance, it is very important to calculate the true environmental costs of the entire lifespan of a building, which can depend, in part, on the building materials used (see box 2-32).[664] Governments can use tools such as the "net present value plus" calculator to estimate the true cost and value of a capital project by incorporating traditionally non-costed impacts, such as environmental degradation and carbon emissions, as well as benefits like environmental resiliency.[665]

Box 2-32

Technology for sustainability in the cement industry

Concrete is the most produced material in the world at 4.2 billion tons per year, with most of the demand for construction projects in fast-growing and emerging economies. The high volume of production makes the global cement industry one of the largest producers of CO_2, accounting for five to ten per cent of global emissions.

In wood construction, the carbon bound by trees is retained in structures and furnishings for a long time, reducing the carbon footprint and affecting the overall environmental impact of the construction industry positively. Using wood reduces the carbon footprint of the construction industry when evaluating the entire life-cycle of wood from the raw-material through manufacturing, use and recycling. Wood or glue wood can be use as frame and facade construction material in detached houses but also in multistory block of flats. For example, Finnish and Swedish companies have been developing cross-laminated timber and laminated veneer lumber technologies that enable large element construction in controlled conditions.[666]

Nonetheless, for much urban construction the most feasible alternative is cement, so viable solutions need to focus on reducing the emissions of cement production. Conventional Portland cement is made by heating ground limestone and clay at 1,400°C and 1,500°C to produce nodules of clinker, which are then ground and mixed with other materials to produce cement. Production of clinker is energy- and CO_2-intensive. Also, the CO_2 embodied in limestone is released during production.

A joint research team from EPFL Switzerland, the Indian Institutes of Technology Delhi and Madras, Development Alternatives/TARA and the Cuban institute Centro de Investigación y Desarrollo de Medicamentos has developed limestone calcined clay cement. This new cement reduces the clinker content by 50 per cent. Clays are produced at a lower temperature and do not release embodied CO_2. Limestone is used as is without burning. As a result, CO_2 emissions are 30 per cent lower that for conventional cement. Using limestone calcined clay cement instead of conventional cement can save up to 400 million tons of CO_2 per year by 2050. That amount equals France's entire yearly emissions or one per cent of global emissions.

Limestone calcined clay cement shows very similar performance characteristics to traditional cement and even outperforms it in some regards such as resistance to chloride and alkali which can cause "concrete cancer". Because it uses less energy in production, limestone calcined clay cement is also approximately 25 per cent cheaper, and governments can accelerate production using tax incentives.

The concept of land value capture is rooted in the idea that indirect beneficiaries of transport and other infrastructure improvements should share the costs and the risks. The Crossrail project in London, for instance, incorporated public and private funding to build new rail infrastructure, in part because the business community saw that the project would benefit their bottom line by improving the city's transit situation.[667] More generally, land regulation and standards are some of the most powerful tools that decision makers have at the municipal level to guide urban development onto a sustainable pathway.[668]

Box 2-33

Leaving no one behind: three transport examples[669]

A critical means of decoupling urban growth from increased environmental degradation is using an advanced public transport system of effective mass transit and attractive "active mobility" (walking, biking) options. Private cars are responsible for 60 per cent of transport-related emissions even though they account for only one third of total urban travel, and that, combined with the congestion and traffic fatalities, mean that the automobile city is not compatible with achieving the 2030 Agenda. Cities are taking integrated approaches to their transport systems, incorporating technology, encouraging sustainable behaviours and making long-term governance and financing decisions.

Sustainable mobility management in Portugal – The Centre of Engineering and Product Development in Portugal, has developed mobi.me, a solution for better and more sustainable mobility management that monitors CO_2 emissions in real time. Working in collaboration with local authorities and communities, mobi.me allows city managers to monitor and promote mobility behaviours that are more sustainable and helps users become more aware of their carbon footprint.

A smart night bus in the Republic of Korea – Owl bus is an intra-city night bus service in Seoul that runs from midnight to 5:00 am. Seoul Metropolitan City, partnering with KT Corporation, designed the optimal night bus routes using big data. KT Corporation collected data on mobile phone call history and taxi rides across the city to visualize the moving pattern of citizens on a map. The information systems connected inside the vehicles enable comprehensive control of bus operations and efficient adjustment of intervals, while providing users and drivers with real-time operation information. The Owl bus was designed to accommodate the city's late-night commuters and lessen financial burdens on the economically disadvantaged, such as self-employed small business owners.

A rapid transit bus service in South Africa – Johannesburg is pioneering sustainable urban transportation in Africa with their Rea Vaya Bus Rapid Transit system, the continent's first full bus rapid transit system. A major goal is to provide access to marginalized communities, especially low-income areas still recovering from the apartheid era. In the long term, the city hopes to reach more than 80 per cent of the population and to stimulate economic growth, opportunity and inclusion. Rea Vaya also aims to have reduced CO_2 emissions by 1.6 million tons by 2020, as people transition from private cars and taxis to buses.

People-centred urban development

Liveable cities place people – not businesses and not automobile transportation patterns – at the centre of all planning decisions. Investing in urban planning and design will allow cities in developed and developing countries to proceed in a strategic manner, prioritizing high-quality and resource-efficient water, waste, transport (see box 2-33) and energy systems. National and municipal governments will make land use and spatial planning decisions to strengthen the ties between cities and their peri-urban surroundings, acknowledging the important role of secondary cities, for instance, in linking farmers to input and output markets, and to serve as logistics hubs for the transport of goods. Cities can thus encourage diversification of economies in developing countries and enhance livelihoods and quality of life for urban, peri-urban and rural citizens.[670]

As part of that approach, innovative governments, a committed private sector and an active citizenry can work together to foster naturbanity, a close connection between people and nature to protect biodiversity, enhance human health and well-being, and strengthen climate resilience.

The ideas of naturbanity and urban metabolism conceptualize cities as ecosystems, with humans and the natural world taking and giving and taking again, all within a sustainable framework.[671] By thinking of the city in these terms, decision makers will prioritize renewable low- or no-carbon energy, water efficiency, including reusing and recycling grey water, and local and sustainable food production.[672, 673]

Nature-based solutions, such as maintaining wetlands and green spaces to support water supply, urban runoff and temperature regulation in a city, can substitute for more energy- and resource-intensive options.[674, 675] Parks, trees, urban gardens, rivers, coastal areas and others can provide invaluable benefits in terms of livelihoods, community building, human health, food security and spiritual well-being, as well as the intrinsic value of nature for nature's sake.[676, 677, 678] Studies have shown that reduced contact with the natural environment and

biodiversity may adversely affect the human symbiotic microbiota, as well as emotional and psychological well-being.[679]

People-centred development is inclusive and participatory and rooted in local culture and heritage (see box 2-34). Studies have found that climate adaptation measures aimed at people living in informal settlements or those addressing industrial pollution, for instance, are most effective if urban civil society and those communities most at risk are involved in decision making and implementation.[680, 681]

In cities in both developed and developing countries, community groups and civic organisations contribute to service provision, accessibility and quality of public spaces, and the local economy.[685, 686] For example, in São Paolo and in many European cities, community actors have started to take care of public spaces, and in Kitale, Kenya citizens have led transformation in waste-management practices to reduce negative health impacts while improving livelihood prospects.[687, 688, 689, 690]

People-centred urban development promotes equitable and symbiotic relationships with the surrounding peri-urban and rural areas. Governments and citizens alike are increasingly recognizing their own vested interest in maintaining the ecosystem services that support them. New York City, for instance, invests heavily in c onservation of the upstream watershed areas that the city relies on for freshwater supply. A number of African cities are forming partnerships with surrounding communities to bolster the farms and ecosystem services that provide food security and other resources to urban areas. In Durban, South Africa, land-use planners are investing in reforestation in nearby peri-urban areas for climate adaptation and as a buffer to a large landfill.[691] A recent study on European and North African cities on the Mediterranean border showed that the capacity of peri-urban areas to supply urban ecosystem services increased in the last 20 years for the four North African locations studied and three out of the eight European ones.[692] Sudden surges of population and humanitarian crises can threaten to overwhelm existing systems and require proactive and inclusive planning and management (see box 2-35).

Box 2-34

Architecture to reflect regional culture and advance the Sustainable Development Goals: examples from the Middle East

Architecture and design shape people's lived experience through their built environment, and today's practitioners are considering sustainability in all its aspects as a central principle, emphasizing resilience, climate-friendly design, accessibility and the identity and heritage of a city.

The Middle East region offers a number of illustrations, as the architecture of the region embodies its historical, cultural and religious influences while also pursuing innovative solutions for sustainable urban development that are rooted in the regional climate, building materials and way of life. In Lebanon architects are incorporating the local practice of orienting buildings to take advantage of prevailing winds, using local stone with its cooling properties and designing homes with the traditional design of a central hall around an interior water feature and courtyard with access to all the rooms, improving circulation and cooling. Wind towers are natural ventilation systems developed in the Middle East; using those kinds of traditional designs have the potential to decrease energy demand.[682] Municipal and national authorities are actively encouraging the preservation of historic design, notably in the reconstruction of Beirut's downtown, as well as in Byblos (Jbeil), Batroun, Deir El-Qamar and Douma. The designers in the region are also incorporating universal design or inclusive design, a principle that seeks to create an environment designed for all people, regardless of age and ability. The United Arab Emirates, for instance, has committed to improving access to all parts of urban and peri-urban life, including recreation, as evidenced by the recent addition of accessible beach pathways to the ocean.[683, 684]

City networks

The 2030 Agenda emphasizes the importance of sharing good practices across territories and regions. In addition to the "science of cities" described above, city leaders can learn from one another through participation in city networks, coalitions and other initiatives.[694] For example, the C40 Cities Climate Leadership Group is a group of 90 of the world's most populated cities, which represents more than 650 million people and one quarter

Box 2-35

Inclusive urban planning: water management at Zaatari camp[693]

Urban development challenges that are difficult in peacetime and made exponentially more complex and problematic in conflict or post-conflict settings. The conflict in the Syrian Arab Republic has created a humanitarian crisis for the surrounding countries, and those fleeing the war often find themselves in extremely water-stressed areas. After war broke out, international refugee organizations and other partners quickly established the Zaatari camp to accommodate the displaced people, and the camp soon became the fourth-largest city in Jordan. The size of the population overwhelmed the water and sanitation services of the camp, and, as a result, disease spread rapidly, as did tensions with host communities, which suffered from water stresses of their own.

The Jordanian Ministry of Water and Irrigation took action to address the crisis, initiating a multi-stakeholder consultation including refugee groups and the local host communities, international NGOs and multilateral humanitarian agencies. With inclusive and strategic planning, the government and its partners built new wells and rehabilitated and repurposed existing infrastructure, saving costs and providing improved service to camp residents and the surrounding peri-urban areas. The water services are complemented by a solar power plant, built with funding from the Government of Germany.

of the global economy. It was put in place in 2005 for tackling climate change and driving urban action that reduces greenhouse gas emissions and climate risks while increasing the health, well-being and economic opportunities of their urban citizens.

The links between cities are based on a variety of factors. They rely on global markets for their trade, and there is the clear appeal of sharing good practices among comparable peers. A recent study found that membership in one or more environmental networks spurs action, especially when the goals of the networks reflect existing policy priorities of the mayors and their constituencies.[695] The study finds that cities benefit from the expertise and experiences of peer or larger cities. For instance, Portland, Oregon, built on the experience of fellow C40 members to launch a green bond program, and Chicago, Illinois, learned from peer cities in Europe and elsewhere as it developed its bus rapid transit system.[696]

Many of the international collaborative partnerships among city governments arose in the past two decades to address climate change mitigation and adaptation.[697] By taking joint action, cities amplify the impact of their policy decisions, which can complement or even substitute for action, or lack of action, at the national level.[698] Mayors of C40 cities, for instance, have pledged that their cities will use only emission free buses starting in 2025 and that by 2030 a major area of their cities would be emission free by 2030.[699] Nine African cities – Accra, Addis Ababa, Cape Town, Dakar, Dar es Salaam, Durban, Johannesburg, Lagos and Tshwane – have pledged to cut carbon emissions to zero by 2050.[700]

City networks are finding areas of common experience and common ground to learn from one another, including about sociotechnical innovations and how to standardize methods for urban emissions measurement and reporting.[701] The Urban Transitions Alliance, for instance, is a partnership among industrial legacy cities in Europe, North America and China that are working to move from systems built on fossil fuels and heavy industry to diversified, sustainable urban systems that prioritize local value chains and decent livelihoods and quality of life for all citizens.[702] Membership in city networks can also provide important resources, including technical assistance programs, sharing of case studies and other good practice reports, conferences and other opportunities for face-to-face exchange for mayors and staff to build relationships and even foster some constructive competition. Each year, the European Commission, for example, names one city as the European Green Capital to reward green development and innovation.[703]

2.10. Entry point 6 – Global environmental commons

Key messages

1. Access to the global environmental commons (biodiversity, land, atmosphere, and oceans) is essential, but they are being depleted and degraded, and the impact is felt beyond national borders. There is thus an urgent need to manage how natural resources are extracted from global commons and how the resulting waste is managed.

2. Global environmental commons are intrinsically linked, and they ignore national frontiers. The Earth system's recovery and resilience imply anticipating the feedback effects between commons to maximize co-benefits and minimize trade-offs at global and local levels. The management of global commons must explicitly address environmental injustice, avoiding unequal use of resources and by repairing the damage already caused, through a combination of technical, financial and political interventions.

3. The stock of natural capital provided by global environmental commons is currently deteriorating beyond its rate of renewal and lacks proper valuation from markets and public policies. Fair access to global commons, which can reduce inequalities, relies on global governance as well as a plethora of actions at all levels.

4. Policies to protect global environmental commons can address hard-to-change behaviours in economies and lifestyles through incentives, taxation and regulations, such as progressive carbon-taxation mechanisms. Creating structural shifts in consumption behaviours through both economic and regulatory incentives and cultural transformations of norms and practices can also contribute to the protection of global commons.

5. Transnational agreements are key to the protection of the commons, and adaptive governance involving a wide range of institutions and stakeholders can help ensure their sustainable management. Science diplomacy can further strengthen the protection of global commons and help establish partnerships for solving conflicts and for the sustainable management of commons.

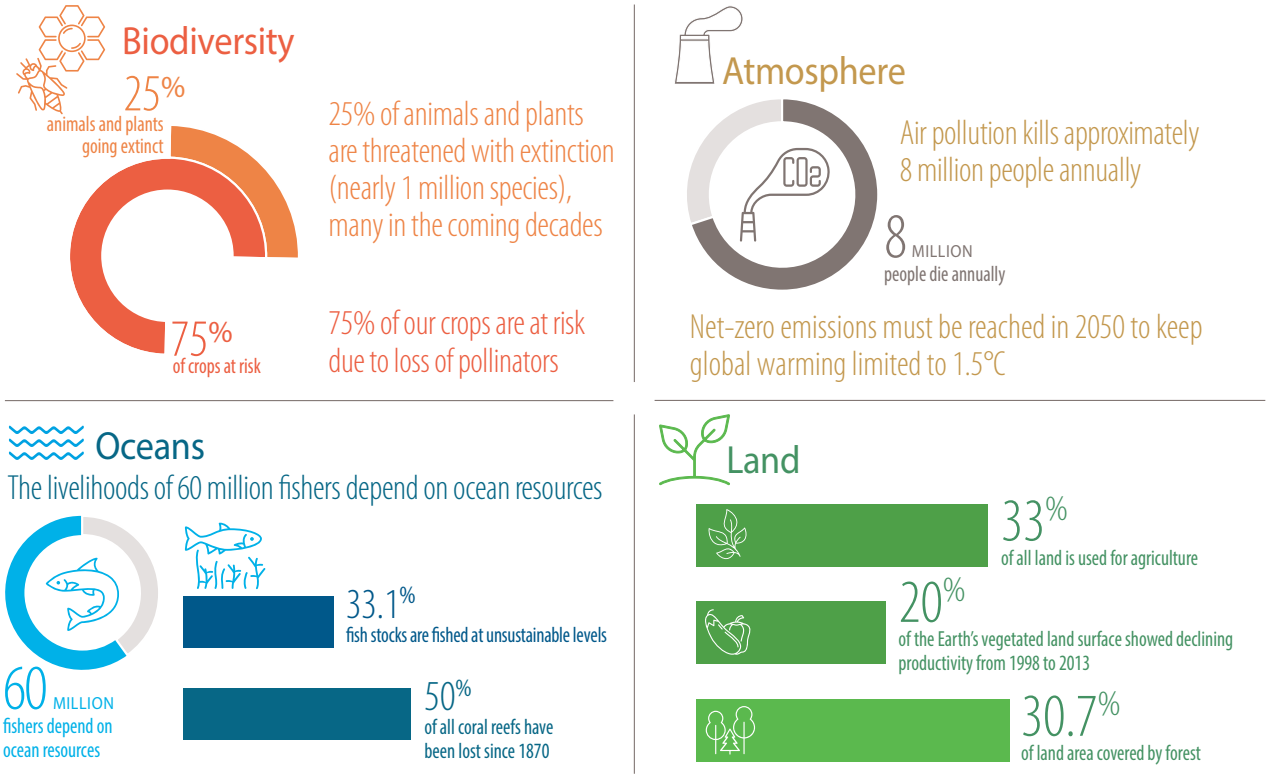
According to international law, global commons refers to four specific areas that fall outside of any national jurisdiction: the high seas, the atmosphere, Antarctica and outer space. Discussions of sustainable development and environmental protection have lately included other commons, which may lie within well-defined national or regional jurisdictions, but whose continuing existence confers benefits beyond them. Those include tropical rain forests, land, biodiversity and climate.

The current report focuses on the global environmental commons defined in that broader sense, comprising various large-scale biomes and systems that contribute directly or indirectly to the functioning of the Earth system and hence to supporting life, including biodiversity, the atmosphere, oceans, the cryosphere, forests and the hydrosphere.[704] Those commons make up a stock of natural capital from which flows benefits often shared across humanity. For some, such as forests, holdings, tenure rights and usufruct may overlap, but are not necessarily mutually exclusive with the concept of commons. Actions on global environmental commons should help secure human well-being and the survival of all living species.

The stock of natural capital is currently deteriorating far beyond its rate of renewal. Overexploitation of the global environmental commons, coupled with emissions of harmful polluting substances, radiation, waste and overuse of hazardous chemicals, is leading to potentially irreversible changes and putting the Earth system's stability at risk. Our actual demands on the global environmental commons have become so great that they are influencing the Earth system as a whole.

Achieving the Sustainable Development Goals requires that we reduce the pressure on those commons. At present, economic development is leading to an even larger environmental footprint – a trend that must be reversed if we are to secure human well-being and support sustainable economies and businesses without subjecting the global commons to mass extinction of species, deforestation, land degradation and unmanageable amounts of waste dumped and emitted. Wastes generated by human activities, including hazardous chemicals, plastics and e-waste, have reached levels beyond the Earth system's absorption capacity. Hence, there is an urgent need to decarbonize human activities, manage how resources are extracted from the commons, how efficiently they are used, how they are distributed and how waste is managed.

Figure 2-15:
Human survival and the global commons



2.10.1 Impediments

Loss of biodiversity

The diversity of species on land and in oceans plays a key role in ecosystems and the services they provide. However, the 2019 report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services warns that an average of around 25 per cent of species in assessed animal and plant groups are threatened, suggesting that around 1 million species already face extinction, many within decades, unless action is taken to reduce the intensity of drivers of biodiversity loss.[705] Without such action there will be a further acceleration in the global rate of species extinction, which is already at least tens to hundreds of times higher than it has averaged over the past 10 million years.

Many pollinating species have declined in abundance, or are threatened by chemical use and agricultural expansion, putting the production of 75 per cent of our food crops at risk. Globally, local varieties and breeds of domesticated plants and animals are disappearing. That loss of diversity, including genetic diversity, poses a serious risk to global food security by undermining the resilience of many agricultural systems to threats such as pests, pathogens and climate change. That unprecedented loss of biodiversity is driven by several interrelated drivers including climate change, resource overexploitation, chemical pollution, fragmentation of land, invasive species, poaching and the disposal of plastics. It is likely that most of the Aichi Biodiversity Targets for 2020 will be missed, in spite of the fact that supporting conservation and securing a safe operating space[706] for future generations is key for sustainable development.

The interaction between the living organisms on this planet and the physical climate system controls the state of the overall global environment, so the loss of biodiversity reduces the resilience of the biosphere, which is essential for maintaining the climate conditions we enjoy on Earth.[707] Extinctions reduce the genetic diversity of the biosphere, and thus the resilience of biosphere functions under changing climate conditions. The pace at which biodiversity is being lost is unprecedented with currently nearly 1 million species, or 25 per cent of the assessed animals and plants, being threatened by extinction in the coming decades.

Damage to the atmosphere

Climate change, air pollution, stratospheric ozone depletion, and persistent organic pollutants are the four main challenges impacting the state of the atmosphere, and they have important deleterious effects on oceanic and terrestrial ecosystems. Climate change due to human activity disrupts the support, regulation and provision of services of ecosystems while increasing the intensity of hazards such as extreme heat, intense rainfall, floods, landslides, sea level rise and drought. Infections and diseases may emerge and spread faster with climate change, especially when coupled with human mobility. Least developed countries and small island developing States in tropical areas are likely to feel irreversible consequences of climate change before other countries,[416] and they have less capacity to prepare and respond. Conservative estimates give a budget of 420 gigatons of CO_2 for a 66 per cent probability of limiting warming to 1.5°C, and known oil reserves exceed that budget by far.

Air pollution presents one of the highest health risks globally, especially in fast-growing cities in developing countries. According to WHO, indoor and outdoor air pollution kills an estimated 8 million people per year, and, as noted above, 91 per cent of the world population breathes air that exceeds the WHO pollution guidelines. Low- and middle-income countries are home to more than 90 per cent of deaths attributed to air pollution. In cities in cold regions, where energy for heating is in high demand, special attention should be given to fumes from inefficient stoves, particularly in cities in valleys, where reversed temperatures keep the contaminated air trapped above urban dwellers. In developing countries, black carbon produced by incomplete combustion of fossil fuels and biomass has increased along with the human exploitation of forest resources. Black carbon, together with increases in regional fire frequency and intensity, plays a critical role in aerosol-planetary boundary layer interaction and the further deterioration of near-surface air pollution in most megacities.

Changes in the oceans

The ocean needs urgent protection to maintain its pivotal role in providing regulating and provisioning services which, in turn, support most other Sustainable Development Goals. Securing the oceans can feed and provide livelihoods for people while maintaining habitats, protecting its biodiversity and coastal areas and regulating climate change. The ocean performs an important temperature and precipitation regulating function, and it is also a carbon sink that has absorbed some 40 per cent of the total CO_2 emitted since pre-industrial times. Projected changes in the ocean are, therefore, expected to create impacts in the Earth system that will lead to greater global warming. Warming, coupled with ocean acidification due to carbon uptake, creates a double challenge for coral reefs, by reducing their growth, causing increased bleaching and decreasing their storm-protective function. The destruction of coral reefs affects oceans biodiversity because they serve as habitats for 25 per cent of oceanic species. Additionally, reefs play a vital role in the economy and coastal protection of numerous tropical and subtropical countries, including islands and developing countries.

The oceans support the livelihoods of 60 million fishers who derive an income from ocean resources, livelihoods that are threatened because acidification reduces the survival of larval and adult stages of several commercially important fishes. Global marine fish stocks are at risk with overfished stocks, having increased from 10 per cent in 1974 to 33.1 per cent in 2015. Oceans receive an ever-growing amount of land-based garbage, sewage, plastic debris, anthropogenic nanoparticles, fertilizers, hazardous chemicals and oil spills as a result of hazardous technologies. Those endanger marine species and biodiversity, contaminate food chains, pose risks to human immune systems, reduce fertility and increase the risk of cancer. Plastic debris constitutes 60 to 80 per cent of marine debris and converges at high concentration (200,000 pieces per square kilometre) in ocean currents. Human activity

also threatens marine mammals' ability to communicate and find food.

Competing claims on water and land and accelerated degradation

By 2025, 1.8 billion people will experience absolute water scarcity and two thirds of the world population will be living under water-stressed conditions. The situation will ultimately deteriorate if no interventions are carried out, especially since demand for water is expected to increase by 50 per cent. As populations increase, especially in dryland areas, more and more people are becoming dependent on freshwater supplies in land that are becoming degraded. Drought and water scarcity are considered to be the most far-reaching of all natural disasters, causing short- and long-term economic and ecological losses. Addressing land degradation upstream improves access to water in downstream areas. Restoring land raises groundwater levels, increases crop yields and induces positive changes in the fauna of the region, as exemplified by recent evidence from Ethiopia and Niger.

Box 2-36
Sustainable Development Goals for resilient mountain communities[708]

Vulnerability to climate change is intricately linked with sustainable development. That is particularly true for the approximately 900 million people who live in the world's mountain regions, which are among the most sensitive to climate change. Those people have high levels of poverty, and, in developing countries, around 40 per cent face food insecurity. If they are to have a sustainable future and cope with climate change, they will need greater capacity and resilience. That calls for considering the specific context of mountains in implementing measures and reviewing progress towards the 2030 Agenda.[709]

A group of 66 mountain experts in Ecuador, Kyrgyzstan, Nepal, Switzerland and Uganda were asked to identify synergies between targets within the Sustainable Development Goals that aim at building resilience in mountain areas. The assessments highlight how targets that promote sustainable use of natural resources and conserving terrestrial ecosystems (targets 6.5, 6.6, 11.4, 12.2, 15.1, 15.2 and 15.4) are indispensable components for building resilience for vulnerable people and for the implementation of sustainable and resilient agriculture practices (target 1.5 and 2.4). Moreover, providing universal health coverage (target 3.8), promoting education of children (target 4.1) and for sustainable development (target 4.7), access to information (target 12.8), inclusive societies (targets 5.5 and 10.2), as well as coherent policies (target 17.14) allow to overcome inequalities, and contribute to resilient mountain communities. The experts considered that addressing the slow economic development of remote mountain areas involves sustainable tourism (target 8.9) and strengthened rural-urban interlinkages (target 11.a).

Land comprises forests, cropland, coastal areas, rangelands, drylands, mountains and other biomes, as well as cities; each one faces particular challenges in reaching the Goals (see box 2-36). Land is becoming an increasing scarce resource, especially for growing food, with a yearly loss of arable land estimated at 100,000 square kilometres.[710] Between 1970 and 2000, the amount of arable land per person decreased from 0.38 to 0.23 hectares, and by 2050 is expected to decline to 0.15 hectares.[711]

Around one third of the Earth's ice-free land surface – and of global available fresh water – is used for raising livestock. In some parts of the world, notably drylands and other resource-scarce areas where no other crop can be grown, raising livestock may be an efficient use of land, where non-edible plants are converted into meat and milk to feed people. However, in other areas, allocating land to livestock rearing is a non-rational use of resources, because contaminants and greenhouse gases are emitted and more efficient ways of producing more food with fewer resources are excluded.[712]

The growing and competing claims on land across the world and from global to local levels has made it a global commodity. Since 2000, large tracts of land in Africa, totalling an area roughly equal to the size of Spain, have been acquired for ensuring food security in other countries.[713] Large-scale land acquisitions like these create power imbalances between those who can afford to buy land and those who cannot and reduces access to land for local people, who face the risk of evictions.[714]

Overall, maintaining and restoring land resources can play a vital role in tackling climate change, securing biodiversity and maintaining crucial ecosystem services, while ensuring shared prosperity and well-being. Achieving land degradation neutrality, which

is composed of three physical markers: land cover (land cover change), land productivity (net primary productivity) and carbon stocks (soil organic carbon), can become an accelerator of achieving the Sustainable Development Goals. Restoring the soils of degraded ecosystems has an estimated potential to store up to 3 billion tons of carbon annually.[715] Climate-smart land management practices, including, for example, low-emissions agriculture, agroforestry and the restoration of high carbon–value ecosystems, such as forests and peatlands, nearly always come with adaptation co-benefits.

Major risks due to deforestation

World forests have been disappearing at an alarming rate. No less than 1.3 million square kilometres of forests have been lost since 1990, mostly in tropical areas (Latin America, sub-Saharan Africa and South-East Asia), which are equivalent to the size of South Africa. Those forests were cleared for agriculture, access to extractive resources, urbanization and other reasons. In particular, the planet's two largest rainforest blocks, the Amazon forest in Latin America and the Central African forests, are key to global environmental health, because they influence climate change through their crucial role as carbon sinks and storage, affect weather patterns across the two continents and safeguard unique species and biodiverse communities. Their fate is important to everyone, not just today's inhabitants. According to 2018 official data, deforestation of the Amazon rainforest in Brazil has hit its highest rate in a decade.

Beyond national jurisdictions

Natural capital, which encompasses the stock of renewable and nonrenewable resources and is often termed "ecosystem services", has typically not been included in standard economic production functions, largely because it was widely thought that it could be taken for granted. That is no longer the case. Even though it is critical for virtually all kinds of production and most of the Sustainable Development Goals are either directly concerned with or strongly dependent on natural capital, it continues to be degraded. It is essential to halt the destruction of natural capital and instead manage it within boundaries that maintain the resilience and stability of natural ecosystems and allow for resources to renew. Breaching the limits of those systems presents risks of severe social, economic and geopolitical consequences. Nature across most of the globe has now been significantly altered by multiple human drivers, with the great majority of indicators of ecosystems and biodiversity showing rapid decline. Seventy-five per cent of the land surface is significantly altered, 66 per cent of the ocean area is experiencing increasing cumulative impacts and over 85 per cent of wetlands has been lost. According to the Natural Capital at Risk – Top 100 Externalities of Business study, primary production sectors (agriculture, forestry, fisheries, mining, oil and gas exploration, utilities) and primary processing sectors (cement, steel, pulp and paper, and petrochemicals) generated externality costs of $7.3 trillion, or 13 per cent of 2009 global economic output. Some of those externalities already translate into stranded assets for financial institutions in various sectors. Nature managed by indigenous peoples and local communities is under increasing pressure. At least a quarter of the global land area is traditionally owned, managed, used or occupied by indigenous peoples. Those areas include approximately 35 per cent of the area that is formally protected and approximately 35 per cent of all remaining terrestrial areas with very low human intervention. Nature is generally declining less rapidly in indigenous peoples' land than in other lands, but is nevertheless declining, as is the knowledge of how to manage it.

Many of nature's contributions are irreplaceable. Loss of diversity, such as phylogenetic and functional diversity, can permanently reduce future options, such as wild species that might be domesticated as new crops and used for genetic improvement. People have created substitutes for some other contributions of nature, but many of them are imperfect or financially prohibitive. For example, high-quality drinking water can be realized either through ecosystems that filter pollutants or through human-engineered water-treatment facilities. Similarly, coastal flooding from storm surges can be reduced either by coastal mangroves or by dikes and sea walls. In both cases, however, built infrastructure can be extremely expensive, incur high future costs and fail to provide synergistic benefits such as nursery habitats for edible fish or recreational opportunities. More generally, human-made replacements often do not provide the full range of benefits provided by nature.

The global environmental commons are being degraded largely because negative externalities are not treated by economic markets, leaving the affected communities and societies as a whole to bear the brunt of the damage. There is some control through regulation, but often the cause is in one national or regional jurisdiction while the damage may be in many others. A global example of that kind of environmental injustice is climate change. Most of the CO_2 in the atmosphere

has been released by the industrialized countries and the richest 10 per cent of people in the world are responsible for around half of global emissions.[716] Meanwhile, those who have released far less are most exposed. Developing countries and specific groups of countries such as small island developing States, mountain communities and Arctic communities now have to endure storms, sea-level rise, ice withdrawal and other extreme climate hazards. Moreover, many tropical countries will endure earlier ecosystem transition and the dramatic effects of climate hazards than industrialized countries.[717] That imbalance is reflected in climate negotiations and claims for financial and technological support from advanced economies to the most vulnerable countries. One such mechanism supporting vulnerable countries is the Green Climate Fund, which seeks to ensure a balanced allocation of funds to adaptation and mitigation projects, as well as ensuring that developing countries access funds directly for a better integration in their climate national action plan. Allocation of funds to that end have been at times challenging, although to date those requirements seem to be fulfilled. [718, 719]

Moreover, the infrastructure through which we access global commons is often owned by the private sector. For example, around half of all marine sequences included in gene patents are registered by a single corporation.[720] That warrants the need for involving the private sector in the management of global commons and also creating the framework and regulations limiting the damage the private sector can inflict to the global commons.

2.10.2 Levers for transformation

All aspects of the global environmental commons are mutually supportive.

Sustainable land management and the adoption of conservation agricultural practices can support biodiversity and nutrient cycling, provide good-quality water, and help with adaptation to and mitigation of climate change.[721] In return, mitigating climate change can reduce the stress on land by reducing the frequency and intensity of extreme events and hence support ecosystems. Recognizing the links between biodiversity and ecosystem services can support achieving the 2030 Agenda with 41 targets across 12 Sustainable Development Goals, including both human well-being and environmental goals.[722, 723]

Governance

Many people profit from the Earth's resources – at the local, national and global levels. When those resources are part of the global environmental commons, those who benefit from resource use may not bear the social and environmental costs of their actions or bear them only in a diffuse way beyond the jurisdiction of national laws. That makes it difficult to recognize and establish trade-offs.[724] Most uses of the global environmental commons generate specific benefits for some families, small groups, private firms, and local, regional, and national governments.[725] Dilemmas arise when they take far more than their fair share and overexploitation threatens sustainable renewal of the existing stock of natural capital.[726] Hence, the global commons needs adaptive governance at the interplay of actors with diverging interests.[727]

Governance for the global commons needs to be flexible and polycentric, involving diverse institutions, overarching rules, mutual adjustment, local action and building trust.[728] That type of governance can create conditions for mutual learning and coordination.[729, 730]

Institutional diversity – Institutional diversity enables decision makers to experiment with different governance solutions tailored to particular scales and social-ecological contexts. Such experimentation enables societies to learn and adapt their own governance solutions.[731] Solutions for climate change mitigation and adaptation, for example, have proliferated in a polycentric manner over the past decade, ranging from international agreements through transnational networks, national and subnational climate policies, community-based initiatives, social movements and private sector initiatives.[732] They enable local progress in climate governance even where governments that retreat from mitigation commitments.

Overarching rules or goals – Maintaining the global commons relies on multilateral agreements and overarching rules, such as the Sustainable Development Goals, that can support coherence and conflict resolution. Multilateral agreements and platforms, such as the United Nations Framework Convention on Climate Change, the Convention on Biological Diversity and the United Nations Convention to Combat Desertification, or the Strategic Approach to International Chemicals Management (see box 2-37) are mechanisms to protect the global commons and guarantee their global sustainable management. Importantly, each is supported by a formal scientific advisory body, the Intergovernmental Panel on Climate Change, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services and the Committee on Science and Technology of the Convention. That suggests that science diplomacy can improve the management of global commons and support partnerships to manage commons in conflicting contexts. Governments are likewise informed by science as they continue to work for the

conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction. Indeed, the Sustainable Development Goals themselves directly help regulate externalities felt beyond jurisdiction and scales. However, ensuring the sustainability of global commons is not just a matter of global governance; a plethora of actions at all scales, from global to local, and involvement of the most directly affected communities is also important.

Box 2-37

Sustainable management of chemicals throughout their life cycle[733]

The global chemical sector is expected to almost double between 2015 and 2030. Numerous new chemicals will enter the market, adding to the estimated 100,000 chemicals already in production. Chemicals offer significant social, economic and environmental benefits, but many pose serious threats to human health and the environment, thus requiring sound management at all levels. Apart from existing legally binding multilateral environmental agreements, the Strategic Approach to International Chemicals Management offers a voluntary, multi-stakeholder and multisectoral platform for collaborative decision-making, open discussion and information exchange. The Approach supports the achievement of the "2020 goal" on chemicals management agreed at the 2002 Johannesburg World Summit on Sustainable Development.

The 2020 goal calls for the minimization of significant adverse effects on human health and the environment, but with a rapidly evolving and growing chemicals and waste sector, it is becoming obvious that the 2020 goal will not be achieved. A future policy framework on sound management of chemicals and waste beyond 2020, bringing together all relevant sectors, raising ambitions and strengthening policies are needed. An intersessional process on the Approach is under way to work out the framework by the end of 2020.

Whatever a future global approach or framework might entail, the chemicals sector must transition towards sustainability, including through enhanced resource efficiency, fostering innovation in materials and taking the whole life cycle of chemicals into consideration.

Mutual adjustments and adaptive governance – Coordinating the interplay among initiatives requires multi-stakeholder platforms, regulated market mechanisms and established legislative boundaries among governance actors, providers and users of the global commons.[734] Decision makers can adopt a range of strategies and governance approaches to enable social learning, or learning new behaviour patterns by observing and imitating others,[735] Some of the most effective action is at the local level in self-organizing, community-based initiatives, particularly for transforming the use of global sinks or resources.[736] But collective action at any scale depends upon building trust.[737] In polycentric governance systems, rather than using than top-down legislative action, relations can instead be ordered through soft inducement, deliberation about collective goals or reputational incentives, and self-organized networks.[738, 739]

Economy and finance

The world now needs new economic models such as the circular economy with production system that enhance Earth resilience and biodiversity while reducing consumption and wastage, ultimately decoupling economic growth from environmental impact. Moreover, the innovations needed for sustainable development offer economic growth opportunities that can increase employment while curbing carbon emissions and reducing the environmental impact.[740]

Science-based target initiatives – Targets can direct corporations towards achieving the Sustainable Development Goals. For instance, companies can contribute to the climate action target to limit the increase in global temperature to well-below 2°C. Such initiatives reward industries that do not generate global damage, including renewable energy, organic farming, responsible fishing and extractives, or public transport.

Alternative business models – Developing countries can follow different economic pathways than the ones developed countries followed – leapfrogging directly to more efficient and sustainable forms of production and service provision. Companies anywhere can pursue alternatives to the business-as-usual approach. An interesting example is the chemical-leasing model. The traditional model of the large-scale sale of chemicals, for example, excessive high-volume sale of paints, solvents and so on for industrial use, results in unnecessary overconsumption, inefficient use and the generation

of hazardous waste.[741] The chemical leasing model is an example of a circular business model[742] in which sales of chemicals are not based simply on the large volume of sales, but rather on optimizing the volume and the value-added service linked to the chemical in consideration of the use to which it will be put, for example, providing only as much specially formulated paint as is needed for the number of items to be painted. That extends the responsibility of the supplier who may manage the entire life cycle. Chemical leasing provides for cost efficiency and is a best practice for contributing to fewer environmental and health impacts related to the production and use of chemicals.[743]

Impact investment refers to investments whose intention is to have social or environmental benefits alongside a financial return. Those investments can provide communities with development projects that are inclusive and sustainable while also rewarding investors. Those types of investments are increasingly penetrating the development market and are suitable, for example, for climate mitigation projects.

Individual and collective action

Pro-environmental individual and collective behaviours can have a significant impact on land management, meat consumption, transportation choice, waste production and water use.[744] Consumers can be guided by the authorities, civil society and political rationalities thereby constructing a sense of individual and shared responsibility.[745] Cultural transformations can also create structural shifts and changes in consumption behaviours.

Environmental stewardship – In the Anthropocene era, human activity has become a geological force affecting the Earth system. The responsibility of world dwellers is thus to become active stewards and agents of change of their own life support systems and find ways of reversing environmental damage.[746]

Science and technology

New techniques and substitute technologies help reduce the stress on the global environmental commons.[747] They can help, for example, in reducing emissions in urban areas and the growing demand for cement in developing countries (see box 2-32 on the cement industry). It should be emphasized, however, that technology needs to be part of overall economic and social changes that lead to lower consumption.

Forest and soil-based carbon sequestration – To offset difficult-to-eliminate emissions, it is possible to encourage negative emissions.[748] As noted above, technologies to capture carbon are rapidly developing but have not yet been proven at scale. Afforestation and soil carbon sequestration remain the two most widely used means for negative emissions, but there are limits to the area that can be reforested and to the amount of carbon that can be stored in soils. Afforestation uses plant photosynthesis to remove CO_2 from the atmosphere. That can involve monoculture planting of a single species, which, while efficient in sequestering carbon, may disturb local flora and fauna, and users of the land predating the afforestation.[749] As the Intergovernmental Panel on Climate Change reported in 2015, the large-scale land use transitions required for effective forest and soil-based carbon sequestration can prove challenging for human settlements, food, livestock feed, fibre, bioenergy, biodiversity and other ecosystem services. In cases in which there are risks for biodiversity and livelihoods, diverse indigenous trees can be planted and communities involved in forest management.[750] Even more effective is to protect old-growth forests, which are generally superior for water and soil conservation than new forests, while supporting biodiversity (see box 2-38), cultural and ecosystem services, climate change mitigation and adaptation.[751] Monitoring of deforestation and land-use change can be greatly helped by the use of satellite imagery.

It is important to take actions to prevent the irreversible deforestation of old-growth forests. Certification systems are one means of reducing deforestation, and support the integration of logging with forest management, especially if the private sector is part of the scheme, as was the case in the East African forest.[752] Negative emissions should be part of an integrated energy system which coordinates green energy supply, energy demand and carbon sequestration or capture.[753]

Box 2-38

Using technology to protect old-growth tropical rainforest in a small country[754, 755]

With a population of less than 800,000 people, Guyana has an 87 per cent forest cover and its system for monitoring, reporting and verification of forest carbon-based CO_2 emissions meets international best practice. The system was originally developed under a REDD+* programme to monitor Guyana's agreement with Norway to avoid deforestation. The monitoring, reporting and verification system now serves many national functions, including measuring progress on the Sustainable Development Goals and providing policy and decision makers with data for maintaining biodiversity, managing deforestation and keeping forest degradation rates low.

Initially, the country's forests were mapped using high-resolution satellite data, ground truthing and other data collection methods. The system now uses freely available satellite data and is executed at low cost, being maintained and managed by national staff. Annual mapping has taken place since 2010 and the monitoring, reporting and verification system provides data on progress towards Sustainable Development Goals Targets for changes in land use and biodiversity (Goal 13, targets 2 and 3; Goal 15, targets 1, 2, 3 and 4).

The monitoring, reporting and verification system provides is a replicable, resource-efficient model for other forested countries, having been developed by international cooperation using satellite technology, science and local resources; combining the talent of local and international experts, academia and governments. Transformative bilateral partnerships can bolster local efforts to meet national needs and support sustainable development. The system promotes access to technological data, recognizes country constraints and provides evidence for policy implementation and sustainable natural-resources management.

*REDD+: Reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries.

2.10.3. Integrated pathways to transformation

Transformation for the global commons can take many pathways and make use of Sustainable Development Goals interlinkages (see box 2-39).[756] Among the fundamental pathways are those related to multilateral environmental regimes, transnational municipal networks, transnational movements, reconciling livelihoods and conservation, and science diplomacy.

Box 2-39

Networked Sustainable Development Goals through a climate lens[757]

The adoption of the 2030 Agenda for Sustainable Development and the conclusion of the Paris Agreement have enormous potential to create co-benefits between the 17 Sustainable Development Goals and the nationally determined contributions.

The German Development Institute and the Stockholm Environment Institute have jointly analysed more than 160 nationally determined contributions and their connections with the Sustainable Development Goals (see www.NDC-SDG.info). The analysis illustrates how climate activities in the nationally determined contributions can support the achievement of many of the Sustainable Development Goals and their targets, going well beyond Goal 13 on climate change. The Goals that are most extensively addressed by activities presented in nationally determined contributions are Goal 7 (affordable and clean energy), Goal 15 (life on land), Goal 2 (zero hunger), Goal 11 (sustainable cities), Goal 6 (clean water) and Goal 17 (partnerships). The themes of each of those Goals and their targets were addressed by more than 500 activities across the 160 nationally determined contributions assessed, highlighting substantial potential for co-benefits and also pointing to the need for policy coherence and coordinated implementation processes. Moreover, the analysis shows that social Goals, such as health, education and gender equality, were addressed less frequently than environmental and economic Goals, pointing to existing gaps that need to be filled.

Box 2-39 (continued)

Beyond the thematic overlaps between the Paris Agreement and the 2030 Agenda, nationally determined contribution climate activities also underline the interlinked character of the Goals themselves. The analysis reveals that even within one climate activity, several Goals and overarching themes can be mentioned. For instance, climate-smart agriculture is linked not only to Goal 2 (zero hunger), but also to Goal 15 (life on land) and Goal 6 (clean water and sanitation). By categorizing climate activities across a set of sustainable development issues, the authors identified a number of cross-cutting themes, such as water and resilience. In nationally determined contribution activities, water is described both as an input and as an essential output to meeting other Goals. For instance, rainwater-harvesting programmes are a prominent measure in climate plans, introducing water-saving measures for increased agricultural production. At the same time, climate plans contain multiple strategies to reduce water loss and adapt to water scarcity. Identifying highly synergistic themes provides guidance to integrated policy design and highlights key areas of focus.

While the analysis only focuses on synergistic connections between nationally determined contributions and the Sustainable Development Goals, it is also essential to assess trade-offs in order to be able to manage all levels of implementation, across all regions and time.

Multilateral environmental regimes are State-led international agreements in specific environmental issue areas.[758] One of the most iconic is the 1987 Montreal Protocol on the consumption and production of ozone-depleting substances.[759] That originated through authoritative scientific assessments of the severity of ozone depletion, combined with the sustained voice of affected parties, social monitoring of emission data and pressure for implementation of the agreements. Private sector research and development investment also led to technological substitutes for ozone-depleting substances, which benefited industrial producers.[760]

Transnational movements – In addition to the city networks described in the chapter above, self-organizing, decentralized national networks are coalescing around specific common concerns and focal points. Prominent examples of movements in support of the global commons include those promoting divestment,[761] agroecology[762] and the environmental justice movement.[763] Such movements can raise awareness, catalyse innovation and build social capital, harness local knowledge and diffuse knowledge about sociotechnical alternatives. At the same time, they can influence local and global political agendas in favour of the global commons.[764]

Reconciling livelihoods and conservation – Many overuses of commons are rooted in unresolved claims on using land or water resources.[765] For fish resources, one option is to establish marine protected areas at transnational, national or subnational scales for conserving marine ecosystems.[766] There is however, the risk that marine protected areas can displace small-scale fishers from their access to crucial livelihood assets.[767] Decision-making on territorial use rights should involve small-scale fisheries, with governments subsequently enforcing and controlling the use of the areas, and settling disputes.[768] It is important therefore to involve fishing communities in the establishment of marine protected areas, as well as in their management and the constitution of boards, and in enforcement, while promoting the technologies and social practices of sustainable fishing. It is also possible to create partnerships among science and transnational corporations. Those can generate leverage within one single initiative over resource uses controlled by major polluters, but they risk reinforcing inequitable corporatist governance structures of the global commons.[769] Livelihoods and conservation can be tackled through domestic laws and regulations enforced to limit the degradation of resources while supporting people, as implemented in Bhutan (see box 2-40).

Science diplomacy – There are a number of examples in which science diplomacy has resulted in environmental protection (see boxes 2-41, 2-42 and 2-43). However, science within governments is underused as a diplomatic tool. The degradation of global commons needs higher emphasis on science diplomacy, extending to the management of ungoverned spaces, such as the seabed, space and cyberspace.

Box 2-40

Bhutan – a carbon-negative country

Bhutan has implemented a number of environmental measures, some of which are legally binding. One is to secure green cover. The constitution requires that 60 per cent of the land be covered by forests.[770] The legal mandate also regulates a compensation scheme, which requires that for any amount of wood used, a governmental tax be levied for planting the equivalent of more saplings of appropriate tree species of wood used.[771] Another measure regulates the production and use of electricity. Bhutan has few coal-fired power plants. Electricity is mostly sourced from hydropower, some of which is exported to India. Those measures have made Bhutan a carbon-negative country. Tourism further supports nature conservation and development. Visitors to Bhutan are requested to pay a minimum daily package fee of $250 to cover accommodation, meals, licensed guides and other travelling expenses, of which $65 is used for social services and infrastructure.

In sum, effective provision of the global commons relies not only on single pathways, but also on interactions among multiple pathways.[772] For instance, transnational climate change initiatives are interacting with the United Nations Framework Convention on Climate Change process and have provided an important foundation for the Paris Agreement.[773] In all those areas, science and technology can make a critical contribution, which is the subject of the next chapter.

Box 2-41

Sustainable hydrology for fresh water as a common good[774]

One target of Goal 6 on water and sanitation is integrated water resources management. The international community has had modest successes in this area, although it is often constrained by lack of knowledge on the water cycle and its evolution.[775] The following two cases exemplify this type of management.

International Centre for Integrated Mountain Development – Since 2010, the International Centre for Integrated Mountain Development has led international scientific collaboration towards researching the impacts of climate change on the cryosphere of the Indus basin, covering the four Hindu Kush Himalaya countries: Afghanistan, China, India and Pakistan. The International Centre for Integrated Mountain Development has a platform for long-term collaboration and coordination among a broad and diverse group of leading researchers, practitioners and policy specialists who work in the region. They have come together to develop series of monitoring and assessment reports, and they contribute to dialogues between India and Pakistan by means of science-diplomacy tools.[776]

UNESCO's Hydrological Programme in West and Central Africa – West Africa and Central Africa have experienced profound changes in recent decades owing to land use change and high climate variability. Many water-management structures developed in the 1960s and 1970s have had negative consequences on sustainability. And in recent years, frequent breaks in hydraulic structures have affected transport and safety. With climate change, there will be an increase in the frequency of hydrological extremes. In this context, since 2015, UNESCO's hydrological programme has considered it urgent to update existing hydrological guides and to extend them to the urban environment. There have been a series of meetings involving the Economic Community of Central African States and the Economic Community of West African States. In October 2016, a meeting of partners was held at UNESCO headquarters to launch that programme and revise hydrological standards for sustainable water management in West Africa and Central Africa.[777]

Box 2-42

Example of a mechanism that mixes multiple pathways in regional cooperation[778]

Actors in the Arctic region are considering a stronger regional orientation towards sustainable development. There are discussions and activities both among Arctic actors such as the Arctic Council, as well as actors outside the Arctic region, such as the European Union and some North Pacific countries with an interest in the Arctic.

The interest arises, on the one hand, from the history of the regional environmental collaboration in the Arctic, which has been built on joint agendas between governments and indigenous communities, strong contribution to the collaboration from civil society and academics, concrete strategies for managing shared challenges, taking into account human well-being and environmental sensitivity.

On the other hand, it arises from the interests and opening possibilities for exploiting the natural resources and sea routes of the Arctic and the awareness of risks if sustainable development is not taken into consideration in the strategies and action plans. The interest towards sustainable development has brought up the idea that the Arctic could be a role model or laboratory for implementing regional sustainable development.

Taking that role, however, requires acknowledging that most countries of the Arctic, and members of the Arctic Council, are among the wealthiest nations of the world, which has important negative spillover effects on the circumpolar Arctic itself and the entire world. Once those questions have been discussed and taken into consideration, the governance model of sustainable development of the Arctic can be recommended as a role model for other regions of the world.

Box 2-43

Science diplomacy[779]

Science diplomacy has become much more than international science collaboration, although that may well have diplomatic benefit. Science diplomacy is primarily the intentional application of sciences, both natural and social, or scientific expertise in furtherance of diplomatic objectives. While science diplomacy emerged in the cold war era as the major actors projected soft power, it is now a concept and a process that can be used by all countries, both developing and developed, to further their direct national interests and those shared with their regional and global communities. The latter inevitably include the global environmental commons.

But structures for effective science diplomacy are often lacking. Few governments have science deeply embedded within their diplomatic approaches; instead they may see science as something primarily to support trade or security negotiations. However, good examples of science diplomacy exist at the regional or bilateral level, for example, the transborder protection of the mountain gorilla in Central Africa or regional disaster management in the Caribbean. To foster science diplomacy a Network of Science and Technology Advisors to Foreign Ministers was formed, which, in turn, is supported by the rapidly expanding network of academics and practitioners in science diplomacy in the Science Policy in Diplomacy and External Relations division of the International Network for Government Science Advice.

Emerging issues are driving a much-needed enhanced emphasis on the shared global objectives and thus the greater need for science diplomacy. Those issues include new technologies, digital and economic transformation, environmental degradation, biodiversity loss, climate change, and the management of ungoverned spaces (for example, the seabed and space). The global and regional challenges now emerging in the face of fracturing or fractured societies also would benefit from scientific inputs to help find solutions. The paradox is that while globalization is being impaired, the need to address the many issues of the global commons is rising. All have scientific dimensions and indeed science will be at the core of their solutions and should be used to help move past geopolitical debates that compromise progress.

Box 2-43 (continued)

The international policy system receives high quality scientific advice on specialized topics (such as the reports of the Inter-Governmental Panel on Climate Change), but more could be done to strengthen links broadly between the United Nations system and the science policy community, so that science can consistently feature as a core input. There may be merit in thinking about whether a more formal and systematic set of relationships between the global policy community and the science community could help. But many other barriers being domestic and new, more effective forms of input within foreign and science ministries are likely also needed. Science can assist with most policy challenges, and that is no different for many diplomatic challenges and those of the global commons in particular.

2.11. Shared responsibility for transformation

Entry points to transformation are not exclusive of the areas highlighted in this chapter. Indeed, when entry points for transformation are considered at the regional, national or local level, there are clear priorities. Likewise, actions in any entry point need to be best suited for local conditions (see chap. 4 for action options for each entry point). Pathways of change through locally agreed entry points should be pursued and can complement and support feedback into other priority areas for transformation, including those illustrated in this report, such as food or energy systems. Water and land, for example, are critical entry points for transformation in many regions, and actions in these areas can have positive impacts across the Sustainable Development Goals (see boxes 2-44 and 2-45).

Box 2-44
Integrated pathways towards sustainable and equitable water access

Access to water is a basic need to sustain life, yet many people lack access to safe drinking water (29 per cent of the global population in 2015),[780] and there are severe strains on water supplies in some regions. In 22 countries, primarily in Northern Africa and South Asia, water stress levels exceed 70 per cent. Among the most vulnerable to water scarcity are women and children in low-income communities in developing countries. Growing population, pollution, urbanization and climate change continue to add further pressure on already stressed water systems, jeopardizing the attainment of Goal 6, as well as also other Goals, including Goal 1 (no poverty), Goal 3 (good health and well-being), Goal 5 (gender equality), and Goal 14 (life below water).

Pathways to transformational change are the focus of this report bringing together context-specific combinations of action in areas defined as "entry points" to support sustainable development and accelerate action across the 2030 Agenda. Water management could be considered one such entry point, where actions spill across individual Goals, and interventions can either build positive synergies (sustainable pathways) or generate unintended challenges and environmental externalities and/or exacerbate inequalities (unsustainable pathways).

In that context, a business-as-usual water management pathway might lead the world, albeit at different scales across regions, to a shortage in water availability of about 40 per cent[781] by 2030. More than 2 billion people live in countries under high water stress today, and levels of water stress are expected to grow as demands for water grow and climate effects intensify.[782] Agriculture is the largest source of freshwater consumption (69 per cent of annual withdrawals globally),[783] and the expansion of irrigated crops in lands with low levels of precipitation and surface water has increased pressures on groundwater supplies.[784] To chart a more sustainable pathway, a systemic approach is needed to address water in a holistic manner using a transdisciplinary methodology that takes into account water's interconnectedness with other systems including those discussed in this report – sustainable economies, food, energy, urban development and others.

Box 2-44 (continued)

A new holistic sustainable pathway for water needs to account for the Goals' interdependencies, inclusiveness, partnerships and, most importantly, leaving no one behind, while capitalizing on new enabling technologies applied to water that were not available during previous decades. Efforts are required to accelerate implementation employing revised science, technology and innovation models, appropriate technology transfer, multi-stakeholder engagement and fostering collaboration across stakeholders including governments, the private sector, civil society and others at the local, national, regional and international levels.

Global and regional cooperation are just as important, especially in shared water bodies. There are 286 shared river basins among 151 countries, whose population amount to 40 per cent of the world's population.[785] As a large number of people live in countries having shared water bodies, cooperation is essential to safeguard that global common good.

Essentially, the entry points to transformation are important to get right for the greatest positive effect and reach of actions and to fit global shared needs, as well as local priorities. Even more important is recognizing that through any entry point, positive outcomes are possible only if levers – governance, economic and financial instruments, individual and collective action, and science and technology – work in concert to strengthen the impact of actions towards shared and agreed goals.

Transformations are not simple or painless, but rapid change can happen when actors work in an integrated way towards agreed goals, sharing and applying available scientific, technological and policymaking knowledge. The positive results of actions are further amplified when multiple outcomes are considered and evaluated by decision makers, as opposed to working in silos in which only a single goal or outcome is considered. There is a rich store of scientific evidence, technologies and knowledge-based solutions across disciplines and regions that must be mobilized to shape action. At the same time, there are also striking gaps in what we know and what we can do. The next chapter delves into how science can contribute to sustainable development.

Box 2-45

Equitable land governance as an integrated pathway to sustainable development

Land lies at the nexus of crucial societal and environmental challenges and opportunities to address food security and livelihoods, poverty, women's empowerment, access to water, biodiversity loss and climate change among others. Land provides the bridge between the Sustainable Development Goals, as decisions on land use, governed by social interactions among stakeholders and institutions, can serve as the very pathways through which the well-being of humans and nature can be secured. More than three quarters of the Earth's terrestrial surface is currently managed to meet a combination of human needs via agriculture, forestry and settlements,[786] with consumers increasingly distant from the sites of production. In addition to rising demands on agricultural production to support more people and changing dietary patterns, landscapes play an increasingly important role in sustaining a wider variety of services, such as flood control, water purification and cultural and aesthetic values; in securing global commons by sequestration of carbon emissions in vegetation and soils; and in protection of biodiversity.[787] More and more, land is a limited resource with multiple, growing, and competing claims by new and old actors alike. As land rents and food prices rise, forests continue to be lost, and land degradation has become a major global challenge.[788]

Governing land to meet the competing demands of diverse stakeholders is a wicked problem, in which the values and aims of management solutions are defined differently by different stakeholders, and where solutions yield additional problems, as inherent trade-offs between production, conservation and other uses reshuffle winners and losers.[789] Such competing claims on land are felt more acutely by the poor, as power differentials in access to land and natural resources lock out local and indigenous peoples, and women in particular, from secure land tenure and property rights. Currently, 2.5 billion people worldwide live on and use land to which they have no secure legal rights, with much of this land used by communities and claimed through customary means.[790]

Sharing the planet fairly with each other and the rest of nature is a collective challenge that demands a new level of societal engagement. Importantly, this requires that the modes of governance move beyond territorial approaches to better manage globalized flows of land-based resources and to address power asymmetries between actors across scales and locations, from the overarching tenet of equity and leaving no one behind. Numerous efforts are under way around the world. By supporting civil society, the International Land Coalition, for example, endeavours to achieve people-centred land governance, assuring land rights as both a fundamental human rights issue and a means to achieve multiple development benefits, investing in and monitoring progress made on 10 broad critical commitments including securing land rights, supporting family farming and protecting land rights defenders.[791] As another example, while international trade is increasingly driving land-based carbon emissions from tropical deforestation,[792] promising initiatives are taking place to improve transparency and governance of international supply chains[793] and support companies to monitor and manage deforestation[794] and further support forest restoration.[795] Finally, land-system science initiatives such as the Global Land Programme of Future Earth[796] provide an improved understanding of complex land-system dynamics and their governance in an increasingly globalized world,[797] and use transdisciplinary methods to include local, lay and indigenous knowledge for transformations to sustainability.

Chapter III

Chapter III

Science for sustainable development

Science lies at the heart of sustainable development. It establishes the factual basis, anticipates future consequences, and contributes to finding pathways to sustainability transformations. Science has always been embedded in society, and more than ever it should consciously engage more with current societal and political challenges and debates. Inspired and guided by the 2030 Agenda, the international scientific and engineering communities should more directly help to shape the future of our societies, in particular through strengthening the emerging interdisciplinary field of sustainability science.

This chapter looks at the science-policy-society interface and considers how science can advance the 2030 Agenda. In that context, science encompasses the natural sciences and engineering, life sciences and medicine, social sciences and humanities, law and more. It also includes the scientists themselves, the evidence they generate and the incentives that drive their research, as well as the systems of funding, the research and educational institutions and beyond. Although not all technological innovations directly originate from science, many scientific advances are key to the process of producing new and more sustainable technologies. Science is further considered as a practice or process: the pursuit and application of knowledge and understanding of the natural and social world following a systematic methodology based on evidence.[798]

Science for sustainable development must provide the evidence to support breaking through the current social, economic and, especially, political impasses to enable creative and transformative solutions that bring forth far-reaching, if not permanent, changes. Achieving the 2030 Agenda cannot be left to chance; it requires deliberate transformations. The political scope for action largely depends, however, on the interplay between the factual certainty that science can produce and sociopolitical factors that can be more difficult to delineate and demand negotiation. As illustrated in figure 3-1, today's problems can be categorized as:

Simple challenges – Largely uncontested scientific evidence forms the basis for decision-making and planning, such as recycling.

Complex challenges – Evidence is not contested, but there are many gaps in knowledge. The way forward can be illuminated by increasing the understanding of coupled social and ecological systems, such as more environmentally friendly farming practices that both local and transnational companies find economical to adopt.

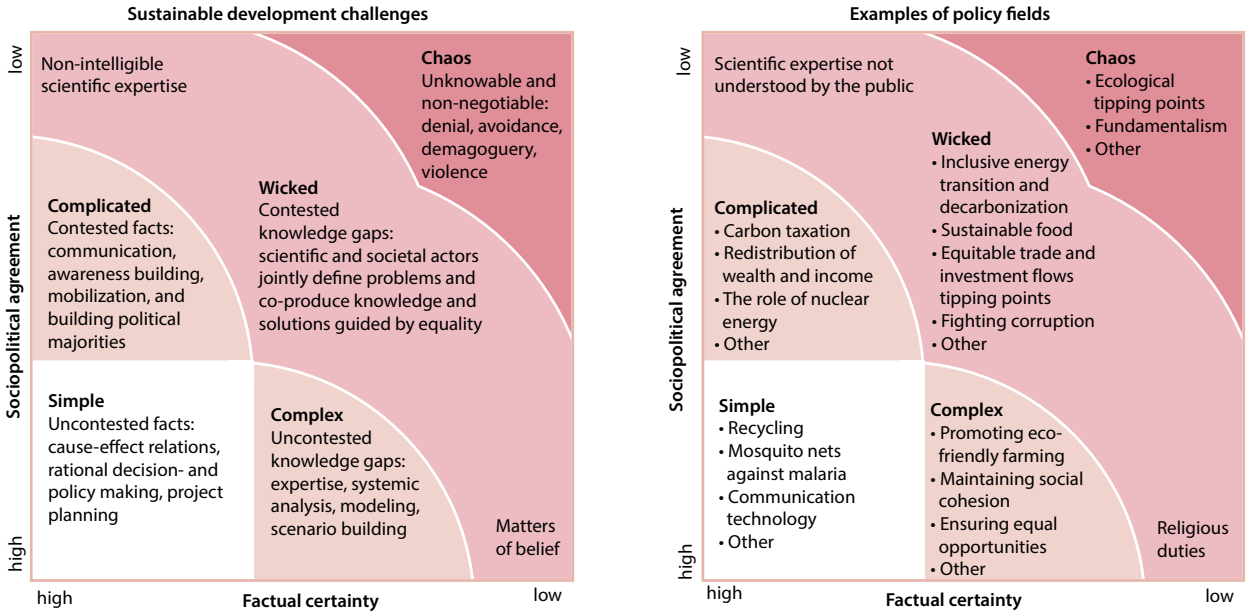
Complicated challenges – Sufficient evidence is available, but implementation requires societal consensus. For example, policies of modest carbon taxation and income redistribution. Those challenges require communications efforts to raise awareness, mobilize responses, spur negotiations, circumnavigate vested interests and create adequate societal demand for action.

Wicked challenges – Not wicked in the sense of evil, but rather wickedly difficult. Here low factual certainty is combined with low societal support. Purely fact-based decisions no longer seem possible, which can make those challenges appear insurmountable. They include decarbonization, for example, or ways of creating sustainable food systems.[799]

Chaos – The issues are unknowable and non-negotiable. Those include the turning of religious fundamentalism to terrorist violence, for example, or the full harm of crossing ecological tipping points.

Figure 3-1:
Types of sustainability challenges

The interplay between sociopolitical agreement and factual certainty influences how we approach sustainable development challenges and what scope we see for political action. Different types of sustainable development challenges are shown on the left, and corresponding examples of policy fields are shown on the right.[800]



Often driven by pressure to produce quick results, many scientists, engineers, and development practitioners continue to rely on simple framing and research, or intervention methods, even for difficult problems, such as the transitions to decarbonized energy systems. Instead, there should be innovative partnerships between science, technology, policy and society. Guided by the 2030 Agenda, scientists in relevant fields can work with diverse stakeholders to build consensus for specific transformation pathways, as described in box 3-1.[801]

Scientists, for whom professional independence and rigour are defining principles, may be wary about such engagement which is necessarily value-laden, worrying that it threatens independence, rigour and even the credibility of science. But that need not – indeed must not – be the case. Scientific research focused on sustainable development has to uphold the highest standards of scientific rigour, in particular transparency, reproducibility, falsifiability and compliance with specific standards of the discipline, but it should also consider relevant societal norms and objectives, as well as people's and communities' aspirations and preferences, and explicitly address these as part of the research.

Complex interactions between scientists and wider society are not new. Throughout history, science has forged alliances with political forces. In some cases, that has served very narrow nationalistic, even imperial interests.[802] Vivid examples include the colonial expansion of western powers from the sixteenth through the twentieth centuries.

At the same time, there are inspiring examples of scientific evidence stirring awareness of global challenges, such as stratospheric ozone depletion, deforestation and HIV/AIDS. And then there are cases of scientific knowledge that marked turning points in public knowledge or debates, but sometimes spurred sufficient action only decades later, as with the discovery of penicillin, Rachel Carson's insights into pesticide use and the contribution of carbon emissions to climate change.[803] Major international environmental agreements have scientific assessment bodies that present evidence to decision makers on difficult and complex topics.

Box 3-1

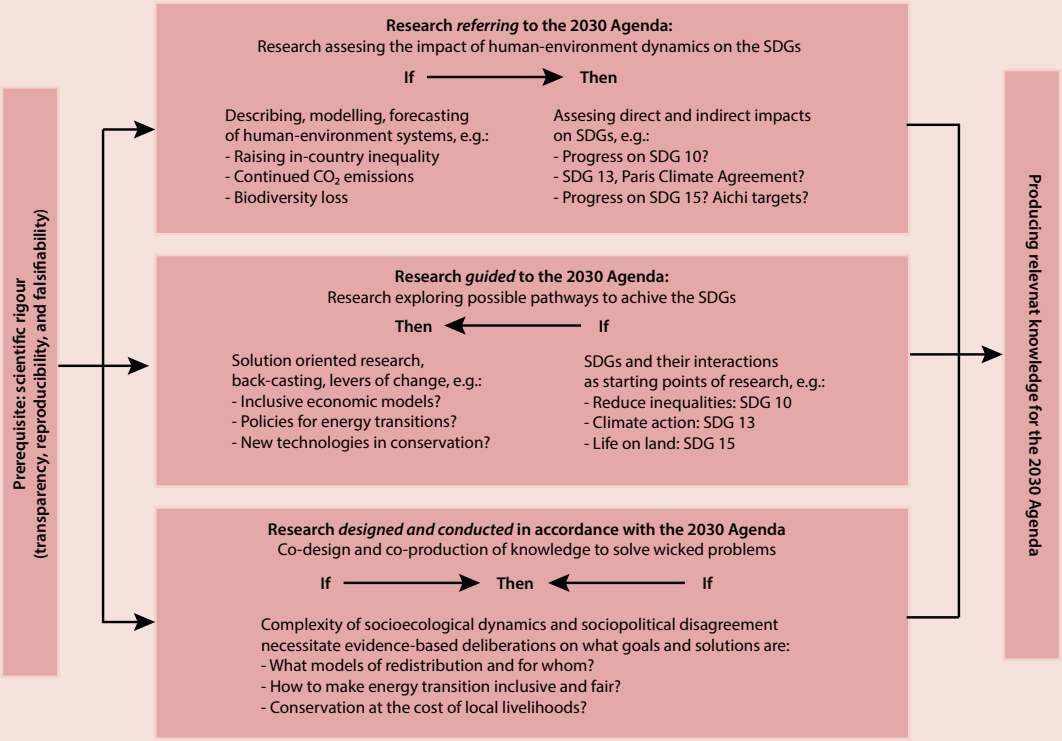
Modes of scientific engagement with the Sustainable Development Goals

Three relevant modes of scientific research engagement with the Sustainable Development Goals can be distinguished. They are not mutually exclusive, but they should complement each other in a pluralistic manner.

Referring to the 2030 Agenda – Assessing the impact of human-environmental dynamics and providing a better understanding of complex causal chains driving the phenomena that affect multiple dimensions of sustainable development. Prompted by any public or private interest, it can aid understanding of the social and/or natural world and its current dynamics or possible futures, for example, by modelling inequality in a specific country.

Guided by the 2030 Agenda – Exploring solutions and possible pathways to achieve the Goals. Scientists take the Goals and their interactions as a starting point and identify promising measures and interventions to realize the objectives of the 2030 Agenda. In that case, while maintaining scientific rigour, the research focus may shift significantly from understanding phenomena (e.g., social inequality) to identifying and detailing ways of improving them (e.g., policies of redistribution, more inclusive economic models).

Conducted in accordance with the 2030 Agenda – Some development issues are both highly contested and poorly understood, as when citizens dispute the environmental and social impacts of foreign direct investment in agriculture. Evidence-based deliberations can build consensus on acceptable trade-offs, which may then point to new knowledge needs. For complex systems that are difficult for different stakeholders to understand, the skills of the researcher may become more important than the explanation itself. Participation in co-production of knowledge typically requires researchers to be explicit about their own values, while striving to preserve the independence, transparency, and reproducibility of their methods.



Clearly, scientific research is not a tidy succession of neutral discoveries and sterile facts. Rather, science is an ever-evolving driver of widespread change embedded in society. Ideally those changes are for the better (e.g., vaccines for eradicating diseases), but sometimes they are for the worse (e.g., nuclear weapons development). Furthermore, social and natural dynamics are tightly interwoven in complex human-environment systems and cannot be fully understood or managed separately. Hence, by bringing about facts, practical knowledge, and technological solutions, science has also a key role to play in the Anthropocene, a period in Earth's history characterized by profound human impacts on the planet as a whole.[804]

In recent decades, scientists have begun to address the web of challenges facing humanity, with interdisciplinary research focused on coupled human-environment or socioecological systems. Those integrated perspectives have been vitally important (see box 3-2). For example, an investigation of the links between deforestation and feeding growing populations shows that people's dietary choices, such as consumption of red meat, has a major bearing on future levels of deforestation.[805] That kind of scientific understanding of complex social-ecological dynamics can reveal whether agreed societal goals, for example, Goal 2 (zero hunger) and Goal 15 (life on land) or Goal 3 (health), will be achieved or missed, what trade-offs are necessary, who will be impacted and how and who holds the key to transformative pathways. As one prominent expert in the Anthropocene put it: "The new normal is about winners and losers, and navigating trade-offs and surprises."[806]

Box 3-2

Decades of interdisciplinary research

Beginning with the pioneering UNESCO Man and Biosphere Programme in the 1960s, interdisciplinary research has received growing support from international programmes, facilitated by the International Council of Science Unions and the International Social Science Council. The related rise in interdisciplinary research led not only to a rapidly expanding body of valuable evidence but also to the symbolic merger of those institutions into the International Science Council.[807]

Major improvements in data availability and new methods, such as integrated modelling and scenario building, have enabled exploration and discussion of possible trajectories of environmental change and given birth to initiatives like The World in 2050, which explores transformational pathways to the Sustainable Development Goals and beyond.[808] Taken together, those efforts have painted a vivid portrait of a planet under pressure and highlighted the risk of rising inequalities that imperil the sustainability of economies, societies and communities.[809]

As the guardian of evidence-based knowledge, science also has unique responsibilities. Scientists and scientific institutions and actors in relevant fields should therefore no longer measure success mainly on the basis of research outputs in the form of raw data, models, or scientific articles. They should also consider how their work can be communicated so that citizens everywhere grasp the need for change and feasible ways forward. UNESCO's recommendations for scientific researchers represents an important tool for ethical guidance and defining rights and responsibilities in research.[810] In particular, more direct collaboration between scientists, policymakers, civil society and business need to address ecological and social crises.

3.1 The 2030 Agenda: a shared compass to harness advances in science and technology

Key messages

1. Science and technology are powerful agents of change for better or worse, depending on how they are steered. Guided by the 2030 Agenda, intensified science-policy cooperation can harness breakthroughs in our understanding of human-environment systems to enable the achievement of the Sustainable Development Goals.

2. International scientific assessments can synthesize existing knowledge and build consensus on key insights. They also provide crucial advice for policymaking. Going forward, more effort is needed to integrate regional perspectives and maximize synergies between different assessments.

3. The urgent need for transformations towards sustainable development demands that we strengthen the directionality of science on behalf of a mutually beneficial "moon landing" for humanity and the planet. Researchers, engineers, science policymakers and funding agencies can adopt the 2030 Agenda as a shared compass to increase the relevance and benefits of science and technology for the global community.

3.1.1. Guidance from the Sustainable Development Goals

Science can support and be guided by the 2030 Agenda, with its 17 Goals and inherent trade-offs and co-benefits. Engagement on behalf of the Goals can be facilitated by:

A knowledge platform – A globally coordinated, and United Nations supported, knowledge platform that enables country-by-country collection, synthesis, and public sharing of the rapidly growing – but fragmented – body of scientific knowledge relevant for sustainable development. The structure could be matrix of Sustainable Development Goals, targets, and interactions integrating local, national, and global levels of observation.[811]

Expert panels – Permanent national and international scientific expert panels and advisory councils for sustainable development. Examples include the German Advisory Council on Global Change or the recently appointed French Defense Council on ecology and South Africa's Human Sciences Research Council. Governments can also appoint chief scientific advisors.[812]

Science-policy networks – Dedicated, long-term science-policy networks, global South-North collaborations and communities of practice. Examples include the International Network for Government Science Advice, operating under the auspices of the International Science Council (see Box 3-4).

Science diplomacy – Science diplomacy is primarily the intentional application of sciences, both natural and social, or scientific expertise in furtherance of diplomatic objectives. While science diplomacy emerged in the cold war era as the major actors projected soft power, it now encompasses a body of knowledge that can be used by both large and small, by both developing and developed countries (see box 2-43).

Science – society co-learning mechanism – Collaboration in which scientists and societal actors at local, thematic, city and national level innovate sustainable solutions and develop, test and practice new routines in everyday life and business.

Research outreach – Funding research outreach activities and collaboration with cultural and wider educational institutions, to engage in common art exhibitions, for example, film screenings, panel discussions and research fairs.

Media skills – Major investment in the development and maintenance of public and private media skills in science journalism and communications.

Box 3-3

Strengthening the science-policy interface[813]

In many parts of the world science and technology communities, the organizations and sectors in which they work, as well as those who support them, are increasingly orienting their work towards the Sustainable Development Goals. Within the United Nations system, several mechanisms enable science and technology communities to interface with policy processes geared towards advancing the Goals. Those must be further strengthened through improved coordination and more inclusive engagement of science and technology communities from all parts of the world. The International Science Council, the World Federation of Engineering Organizations and the InterAcademy Partnership are among those who work to respond to that challenge.

In the context of global United Nations intergovernmental processes on sustainable development, the Earth Summit of 1992 recognized that achieving sustainable development would require the active participation of different stakeholders, and invited nine "Major Groups" to contribute. One of these is the Scientific and Technological Community Major Group. At the global level, the International Science Council and the World Federation of Engineering Organizations operate as the organizing partners of this Major Group, helping bring inputs from this community to several United Nations intergovernmental processes related to sustainable development.

The International Science Council (see www.council.science) brings together more than 140 national scientific organizations, including academies and research councils, and 40 international scientific unions and associations. It works to catalyse and convene international scientific expertise on issues of major global concern and to effectively integrate science into policy and public action. The World Federation of Engineering Organizations (see www.wfeo.org) unites more than 110 multidisciplinary engineering organizations throughout the world. The Sustainable Development are a priority domain of impact for both organizations, and both collaborate actively with a range of United Nations bodies.

For the successful implementation of the Goals, it is essential to connect efforts to advance evidence-informed policymaking at the global level to those undertaken at national and regional levels. In this regard the work of the International Science Council and World Federation of Engineering Organizations is reinforced by the InterAcademy Partnership, the global network of over 140 merit-based science, engineering and medical academies (see www.interacademies.org). The InterAcademy Partnership is raising awareness and understanding of the Goals among academies, and encouraging them to engage with national and regional processes related to the Goals to ensure that they can be more informed by evidence.

3.1.2. International scientific assessments

Scientific contributions will help countries navigate the various trade-offs inherent in sustainable development. Progress can also be tracked through a number of international scientific assessments, of which three broad groups can be distinguished:[814]

- *Intergovernmental scientific assessments* – such as the Intergovernmental Panel on Climate Change, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, the International Assessment of Agricultural Knowledge, Science and Technology for Development or the Global Environment Outlook;
- *Scientific-technical assessments* – such as the United Nations flagship reports including the Global Biodiversity Outlook, the Human Development Report and the World Economic and Social Survey;
- *Scientific research collaborations* – such as the Millennium Ecosystem Assessment and the Global Energy Assessment.

Those assessments differ greatly in terms of their scope, scale, organization, participation and perceived degree of policy relevance. However, they all aim to discuss areas of scientific debate, identify common understandings and reach evidence-based consensus on key issues, with a view to informing major policy decisions.

In any scientific field there is scope for disagreement.[815] Differences can result from dissimilar methodologies, varying research questions, divergent sample sizes and time horizons, errors and so on. Such differences can be resolved through international scientific assessments, which provide forums in which results can be shared, compared and tested among peers; synthesized and refined to find the signal in the

noise; and scrutinized to assess remaining uncertainties. Those and other efforts to find consensus can catalyse science, giving rise to new research questions and agendas.

Those assessments generally seek, formally or informally, to guide policies on complex, usually global, challenges. For example, the Intergovernmental Panel on Climate Change, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, the Committee on Science and Technology established in accordance with the United Nations Convention to Combat Desertification have enabled policymakers to determine priority issues and make global and regional assessments.[816] Such efforts seek to bridge the divide between researchers and policymakers. To do so they will need adequate governance structures, knowledge platforms and expert dialogues. They must always engage with multiple stakeholders whose priorities may diverge.

Current international scientific assessments have their limitations. First, they are often limited in capturing important country-specific or subnational differentiation. In particular, they may not adequately reflect the unique challenges faced by small-island developing States, least developed countries and landlocked developing countries.[817] Second, they may fail to offer solutions and pathways to the 2030 Agenda. Typically, they focus on the impacts of human-environmental dynamics on societal goals rather than how such goals can be achieved. Third, they may not always reach agreement or they may fail to resolve major trade-offs, such as managing across the different uses of land – for food production, biodiversity conservation, carbon sequestration or biofuels.[818]

At the same time, it is important to strengthen synergies and collaborations across scientific assessments, including sharing knowledge and databases and harmonizing protocols and procedures. The 17 Goals can serve as the basis for more coherent messages and guide continuing, expanded assessments of assessments under the auspices of the Global Sustainable Development Report.

3.1.3. Beyond the goals

Research should also highlight social, economic, environmental, political or technical dynamics that were unanticipated when the 2030 Agenda was drawn up, and could either significantly advance or jeopardize its achievement. Despite being a vital, globally negotiated vision of sustainability, a number of key issues have been identified as missing, including rapid technological change. By means of an open call, the current Report has collected some others.[819] They include:

- *Ongoing armed conflicts* – The Sustainable Development Goals do not adequately address the many protracted crises around the world that impede or even destroy development and hamper the achievement of the goals.[820] The Goals do not adequately discuss peacebuilding, military spending and arms proliferation.

- *Pastoralism* – The Goals barely mention pastoralism and livestock production systems, though these cover vast land surfaces, are key to millions of livelihoods, can support biodiversity and sustainable land management, have sensitivity to cross-border conflicts and have the potential for climate change mitigation.[821]

- *Spiritual values* – The Goals ignore many of the cultural and spiritual values people attach to natural resources.[822]

- *Culture* – Culture has received insufficient attention as an intrinsic component of sustainable development and must be translated and embedded in national and local development. [823]

- *Drugs* – The significance of drug addiction is overlooked, despite its being highly relevant to the achievement of multiple Goals.

- *Animal welfare* – The clear links between human health and well-being and animal welfare is increasingly being recognized in ethics- and rights-based frameworks. Strong governance should safeguard the well-being of both wildlife and domesticated animals with rules on animal welfare embedded in transnational trade.[824,825]

- *Human genome editing and transhumanism* – These new technologies are potentially a threat to international security.[826]

It is also important to examine the political processes behind adoption of the 2030 Agenda.[827] There have been concerns about the legitimacy of the overall process, the depth of public engagement and the voices dominating relevant discourses.[828] Other criticisms include oversimplified approaches to poverty, lack of consideration of population growth and the absence of mechanisms to resolve inevitable trade-offs between different Goals or different notions of justice.[829]

Institutions aiming to implement the Goals have to deal with these issues and other unexpected developments and new, emerging issues. [830] On the technology front, new developments include digitalization and artificial intelligence (see box 3-4). On the political front, the Sustainable Development Goals also have to engage with competing discourses, such as climate-change denial, pressures on multilateralism, and economic and social paradigms that contradict

Box 3-4
The digital revolution[832]

A key enabler of sustainable development in the coming years will be the digital revolution, constituted by ongoing advances in artificial intelligence, connectivity, digitization of information, additive manufacturing, virtual reality, machine learning, blockchains, robotics, quantum computing and synthetic biology. The convergence of those new digital technologies could be explosive, with many winners and losers.

The digital revolution is already reshaping work, leisure, behaviour, education and governance. In general, those contributions can raise labour, energy, resource and carbon productivity; reduce production costs; expand access to services; and may even dematerialize production.

But there are also clear dangers and downsides, including the loss of jobs, rising inequality, and the further shift of income from labour to capital. With automation and advances in artificial intelligence and robotics, many more workers, even those who are highly skilled, may find their jobs and earnings under threat. While new jobs might replace old ones, the new jobs may come with lower real earnings and working conditions. The fears about increasing inequalities have given rise to renewed interest in a guaranteed minimum income.

There are several other perceived threats from the digital revolution. Many of those are concerned with security and the invasion of privacy. Cyberattacks or cyberwarfare can interrupt or degrade private and public service delivery. New monopolies are appearing in e-commerce, digital advertising, social media and cloud services. Social media can be manipulated, undermining democratic processes. The personal use of online technologies can be addictive and cause the onset of depressive disorders. Special dangers relate to advanced weaponry. A more general question is whether the digital revolution as a self-evolving evolutionary process that has generated huge global monopolies is even amenable to social steering. As the digital revolution advances, ageing people need support in order to catch up and become users of those advanced technologies so that they are not left behind.

In the Anthropocene, humans became major drivers of Earth system changes. In the digital Anthropocene humans will also start to transform themselves, enhancing cognitive and brain capacities. Humanity is moving towards new civilizational thresholds. Super-intelligent machines might even develop a life of their own, with the capacity to harm human agents.

The digital transformation calls for a comprehensive set of regulatory and normative frameworks, physical infrastructure and digital systems. An essential priority should be to develop science, technology and innovation road maps and write the principles of digital transformation for sustainable development.

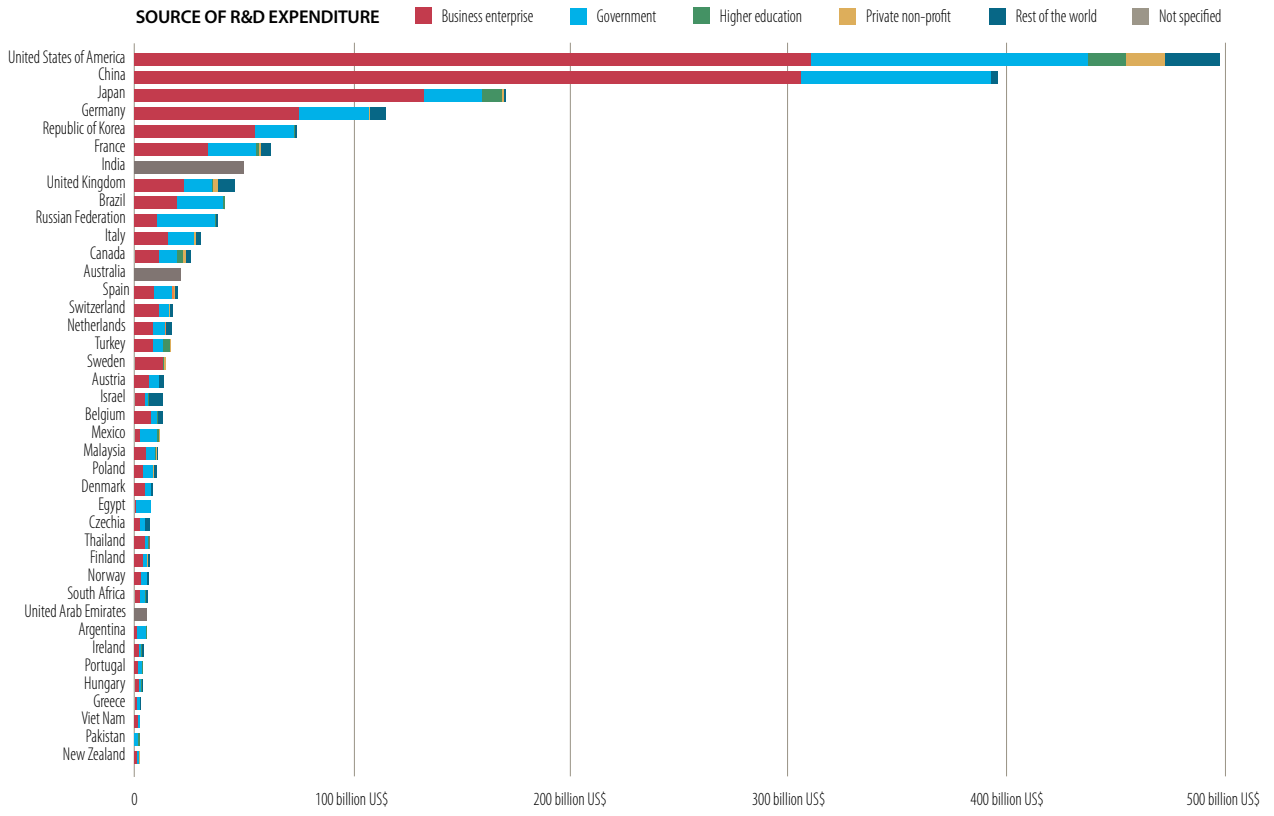
the Goals in whole or in part. Finally, when examining trends and dynamics that promote or threaten to derail the Goals, post-2030 perspectives are also crucial, such as The World in 2050 Initiative that assesses pathways to social and economic sustainability based on a stable Earth system in 2050 and beyond.[831]

3.1.4. A shared mission for the global community

To realize the full power of science for sustainable development, it is important to negotiate the direction of research.[833] In dialogue with society, researchers in relevant fields should define the necessary combination of disciplinary, inter- or trans-disciplinary approaches. In that way, they can create a sense of shared worldwide mission. The 2030 Agenda can help to energize and crystallize a new global effort with a common goal and become a new moon shot for the global community.

One of the most crucial issues is funding. At present, States are currently spending relatively little on research and development to implement the 2030 Agenda. Nowadays, a large proportion of research is driven by commercial interests (61 per cent of all worldwide research and development) or comes from private funds and philanthropic research and is concentrated in certain countries (see figure 3-2). That is worrying because during the post-war golden era of economic growth and invention, radical risk-taking and technological innovation were financed largely by the public sector. Meeting today's sustainability challenges requires rapid, unprecedented funding, both public or private.[834]

Figure 3-2:
Research and development expenditure worldwide, 2015.



Note: Research and development funding worldwide in 2015. Business enterprise comprises private and public enterprises; Government comprises any central, regional or local government units, except those related to higher education services; higher education includes tertiary education institutions and their research institutes, centres and clinics; private non-profit comprises non-profit institutions serving households, and households or individuals; rest of the world includes all institutions and individuals from outside of the economic territory, as well as international organizations and supranational entities.[835]

Furthermore, empowering women in science and technology represents another important measure.[836] Thus, women should be supported and encouraged through education and career opportunities for sustainability science but also by building strong networks such as the International Network of Women Engineers and Scientists, a global network of organizations of women in science, technology, engineering and mathematics.[837]

Science for the 2030 Agenda should also work with other worldwide policy ideas and related initiatives to end poverty. Indeed, the frontiers of science should be pushed to enable equitable transformation and progress towards the "five Ps" of the 2030 Agenda: people, planet, prosperity, peace and partnership.

3.2 Sustainability science

Key messages

1. Sustainability science can help tackle the trade-offs and contested issues involved in implementing the 2030 Agenda. New initiatives are needed that bring together science communities, policymakers, funders, representatives of lay, practical and indigenous knowledge and other stakeholders to scale up sustainability science and transform scientific institutions towards engaged knowledge production for sustainable development.

2. The United Nations should launch a globally coordinated knowledge platform to synthesize existing international and country-by-country expertise on transformation pathways from scientific and non-scientific sources, including lay, practical and indigenous knowledge.

3. Educational institutions at every level, especially universities, should incorporate high-quality theoretical and practically oriented courses of study on sustainable development.

Science and technology have at times exacerbated global problems by contributing to unsustainable growth and climate change, for example or by making efficiency breakthroughs that eventually lead to greater aggregate use of scarce resources.[838] Moreover, the existing science system has failed on occasion to translate its findings on issues such as climate change into workable policy recommendations.[839]

The world now needs more sustainability science.[840] That is a new, more engaged academic field of studies that sheds light on complex, often contentious and value-laden, nature-society interactions, while generating usable scientific knowledge for sustainable development. That means dealing with risks, uncertainty, ethical issues and appropriate use of the precautionary principle. It involves working with affected groups to recognize problems and goals and identify key trade-offs.[841]

Sustainability science has attracted tens of thousands of researchers, practitioners, knowledge users, teachers and students from diverse institutions and disciplines from across the world, notably Latin America, Africa and Asia.[842] That diversity alone sets it apart from many other scientific fields. Typically, researchers use transdisciplinary approaches, bringing together scientific, lay, practical and indigenous knowledge, as well as fundamentally different world views (see box 3-5).[843] A recent example concerns the phasing out of coal in Europe. There was found to be less resistance in the coal-mining regions where scientists, policymakers, and coal miners had come together to jointly identify alternatives for regional development and individual livelihoods.[844]

Nevertheless, in the broader scientific landscape sustainability science remains a niche field. To realize its full potential sustainability, science should be scaled up significantly. That requires new priorities within the research community, for example, expanding research agendas and capacity building, as well as broader transformation of science as an institution.[845, 846]

Box 3-5
Indigenous knowledge for sustainable development

Indigenous knowledge builds on long-term understanding and practices of socioecological systems of various societies across the world. It is a social learning process by which practices and behaviours are adjusted towards embracing better uses of the surrounding environment and contributing to the well-being at individual, communal and societal levels. As such, indigenous knowledge has guided societies and supported sustainable management of resources, especially in regions where practices have been known for hundreds of years. In contrast, Western science often produces knowledge from simulating the real world through modelling. Therefore, not only is indigenous knowledge an important indicator of how sustainable development can be achieved, but it can also complement science and policy by placing them in the local context for better implementation.

Engaging with indigenous people, who have a diversity of know-how and cultures, for new collaborations along the knowledge production value chain are therefore needed for co-producing informed policy, improved evidence and the implementation of the 2030 Agenda. Existing indigenous knowledge on megatrends such as biodiversity, climate change adaptation and land conservation must be documented. More importantly, strong respect and ethics are crucial throughout the process. Harnessing and securing indigenous knowledge must be undertaken with regards to the intellectual property ownership, which belongs to the indigenous people. The Science, Technology and Innovation Strategy for Africa 2024 aims to secures and utilise indigenous knowledge as part of its scientific prioritization.[847]

3.2.1. Transforming science institutions

For sustainability science to realize its potential there needs to be significant adjustments to universities and other research and training institutions.[848] Individual researchers and research initiatives in relevant fields should become part of larger collective research projects and holistic programmes. Long-term research partnerships can identify socially relevant research questions, generate meaningful insights, and bridge the gap between knowledge and action.[849] Researchers often engage in new, experimental platforms and processes at the science-society-policy interface, including those initiated by wider social movements.

The current science-policy environment frequently discourages that kind of engagement. When considering proposals for funding, reviewers frequently apply specialized disciplinary criteria rather than considering the integrated whole.[850] The field is still relatively young, so sustainability science as a discipline lacks recognition, and its researchers have yet to establish powerful groups of peers or journals that are more well recognized. That has consequences, since academic careers are still typically built on numbers of publications and citations in high-impact, peer-reviewed journals rather than on researchers' contributions to societal transformation.[851]

There are also concerns about scientists' capacity and skills. Established academics may not be empowered to design and implement collaborative research efforts and may lack the required competences, skills, time and other resources.[852] Socially engaged researchers can thus find it difficult to combine an academic career with engagement at the science-society interface.[853]

The number of women in the natural sciences and engineering is growing, but men continue to outnumber women, especially at the upper levels of those professions. Even in countries where girls and boys take math and science courses in roughly equal numbers, and about as many girls as boys leave secondary school prepared to pursue science and engineering, fewer women than men pursue those careers. Despite progress in the past 50 years, female scientists win fewer prizes and less money and prestige than their male counterparts. Some quite convincingly argue that long-standing, culturally derived beliefs about gender have shaped attitudes and ideologies about scientific rigour, inducing limitations in laboratory experiments and other research protocols. Promoting gender equality in science has therefore the potential to lead to substantial knowledge, social and economic gains.

The sustainability science community is growing, and it is increasingly engaged in United Nations programmes of global governance. International conferences, global and regional networks, pioneering institutions and new initiatives around sustainability issues are gaining attention, and there are significant new scientific journals such as *Sustainability Science* and *Nature Sustainability*. There is also an increasing number of international initiatives, such as Future Earth, which recognizes the value of interdisciplinary and transdisciplinary sustainability research, as well as funding initiatives such as Lira 2030 (International Science Council); Transformations to Sustainability; Horizon 2020 (European Union) and the Belmont Forum. Further, there is a growing number of universities, research centres, pioneering institutions and transdisciplinary labs dedicated to sustainability science.[854] Finally, various related regional initiatives are on the rise, for example, the African Transdisciplinary Network and the Institute for African Renaissance Studies.

3.2.2. Mobilizing existing knowledge

As yet there is relatively limited scientific knowledge on how to achieve transformations to sustainable development. That will require long-term investment in sustainability science. It is also possible to make better use of existing knowledge. There is a large and underexploited body of lay, local and traditional

knowledge, much of which remains untapped in the minds of non-academic actors working in public policy, business, NGOs and especially among ordinary people in the global South, for example small farmers, who have already found innovative ways of adapting their livelihoods to rapidly changing environments. Further expansion of the private sector research, consultancy work, and philanthropic activity is also giving rise to new sites of knowledge production and expertise.[855]

Those untapped sources should be systematically collected and synthesized in a major international independent assessment led by the United Nations that brings together researchers and a wide range of experts. Guided by the Sustainable Development Goals and the major entry points for transformation identified in this Report, they could then co-produce knowledge on how levers of change can be combined into innovative transformation pathways. That would show how interactions between different Goals can be managed equitably, turning trade-offs into co-benefits. All that information would be held on a new open-access platform. Successful examples of such platforms include the World Overview of Conservation Approaches and Technologies platform,[856] which shares practices of sustainable land management, and the Atlas for Utopias on transformative cities.[857]

Those efforts can be enhanced by big data technologies that can analyse, manage and systematize information on an unprecedented scale.[858] Journals editors and publishers could support such initiatives with special issues and by expanding open access to the wealth of existing publications (see box 3-6).[859]

Box 3-6

Open access to published scientific knowledge[860]

The number of scientific journals, articles and the overall amount of knowledge generated have soared. Too often, however, access to that growing wealth of human knowledge remains restricted and in the hands of commercial publishers, even when the research has been funded by taxpayers and States through universities and other public institutions.[861, 862, 863] For developing research and innovation capacities and fast-tracking innovations for sustainable development, more open sharing of scientific knowledge could play a significant role, especially in the Global South, where scientists typically experience even greater challenges to access the most recent pay-walled academic literature than their counterparts in the North.

While traditional business models of scientific publishing are not conducive to this, there is now a growing momentum for alternative models based on principles of open access. Various open scientific repositories and initiatives enable greater access to scientific articles, setting different levels of use defined by authors. For instance, Creative Commons licenses and institutional rights-retention open access policies may enable researchers to share their work widely while retaining rights over material and publications.[864] Besides the benefits to knowledge users, scientists benefit from having their work shared more widely, as increased visibility can also increase citations.

The European Union and various national funding agencies now require open access for scientific publications they fund. Several philanthropic institutions also require the widest possible dissemination of publications resulting from their research funding.

Finally, libraries and universities in Germany and other countries are forming consortiums to negotiate fixed annual fees with major publishers to make their national scientists' publications accessible worldwide. That "publish and read" model could point the way forward if enough countries work together to unlock published scientific knowledge for the benefit of all. Other models exist, such as the Plan S, which encourage open-access publications.[865]

3.2.3. Education for sustainable development

To implement Agenda 2030, society needs to increase its capacity to innovate and steer change through new generations of researchers and practitioners who can foster multi-stakeholder co-production of knowledge on behalf of a sustainable future. One of the most important parts of transformation should be to build the capacity of young people, especially through universities, which can provide space for increased science-society-policy interaction, while synthesizing knowledge on what works and strengthening the

foundation and rigour of sustainability.[866] Enhanced education for sustainable development also needs to happen in schools and within the adult population at large to increase the awareness of the challenges and the level of information about how to deal with them.

This implies activity in four crucial areas:

Core concepts and competencies – Scientists and engineers must further elaborate relevant core concepts and competencies. That includes reflecting on the role of science in society, considering complementarity between scientific knowledge and lay or indigenous knowledge[867] and focusing on the key skills students need to tackle complex challenges.[868]

Institutional development – This should include sustainability science–related curriculum reform, new theoretical and methodological components and new institutional frameworks.

Course review – Sustainability-related courses must be critically evaluated and adapted across departments.

Partnerships – Universities must cultivate new partnerships beyond academia and connect with various institutions across the globe.

Education for sustainable development, as with many areas of science, research and publication, continues to be dominated by Western institutions.[869] There is still a great imbalance between the global North and South. While sustainable development is paramount in the global South, textbook knowledge and university curricula do not always enable students to realize their full potential for innovation. The 2030 Agenda affords everyone an active role and responsibility in sustainable development. But if people are to take advantage of it, they will need quality education on sustainable development in curricula on natural and social sciences, engineering, law and many others, starting as early as possible and expanding on all levels. North-South research partnerships are a highly effective way of building transformative capacities and concrete applications across countries. They can also benefit from transdisciplinary collaboration, for example, working directly with small farmers and other resource users.[870]

3.3 Partners for transformation

Key messages

1. Governments at every level should institutionalize science-policy-society alliances focused on co-designing, implementing and monitoring context-specific pathways to sustainable development.

2. Actors from science, policy, the private sector and civil society must radically rethink their partnerships and create experimental spaces for collaboration on transformation pathways. Governments should enable co-creation of citizen science and testing of transformational ideas.

3. The highly uneven global distribution of scientific capacity and knowledge access threatens to derail the 2030 Agenda. United Nations Member States must support a major coordinated effort to make all relevant scientific knowledge immediately accessible, especially to low- and middle-income countries, and to build knowledge societies in the longer term.

The 2030 Agenda and sustainability science are based on shared scientific and societal deliberations and decision-making.[871] That requires spaces where researchers in relevant fields, policymakers, other decision makers and affected populations can meet and exchange knowledge and co-design transformational pathways.[872] Citizen science enables participants to make a direct contribution to research, increase their scientific understanding and immerse themselves deeply in learning about global challenges.[873] Those opportunities provide personally transformative experiences. Key spaces include science-policy-society knowledge hubs, networks, think tanks and solutions-focused laboratories.[874] To the extent possible, those should be established at various organizational or administrative levels (global, regional, national and local) and networked to connect actors and institutions horizontally and vertically.

Those hubs should be equipped to receive, store, analyse, refine and further share data, whether global satellite imagery, national censuses, jointly produced community maps or inventories of traditional medicinal

plants. For knowledge hubs with a special focus on spatial data, an important example is the OneMap initiative in Indonesia,[875] Myanmar,[876] and elsewhere.

There is a particular need for medium-scale knowledge hubs to unite stakeholders in neighbouring countries around managing vital shared needs focused, for example, on shared resources like rivers or biodiverse forest and mountain ecosystems. The International Centre for Integrated Mountain Development[877] and the Nile Basin Initiative and its centres, which unite 10 countries around use of common water resources, provide useful models.[878]

3.3.1. Forging new partnerships

Major transformations in areas like energy systems, health, food and urbanization make it necessary to radically rethink partnerships between science, government, the private sector, civil society and more. The Sustainable Development Goals span numerous sectors and distant places, yet each setting has its own unique requirements and potential trade-offs between Goals. Scientists everywhere can join forces with public servants, businesspeople and other citizens to manage such trade-offs fairly.

Scientists and engineers, concerned about the impact on their careers, may be wary of partnerships because of tensions and mistrust. Some may avoid working with powerful State actors or corporations that they associate with prior ecological and social harms, poor accountability or a lack of commitment to equity.[879] Other scientists or engineers may avoid engaging with the rich body of lay, local and traditional knowledge for fear of losing credibility or because of misconceptions about its value in comparison with academic knowledge.

The knowledge and solutions needed to reconcile conflicting demands will probably emerge only from new, even unlikely, alliances.[880, 881] An example is the One Health approach, to improve health and well-being through prevention of risks and mitigation of diseases that originate at the interface between humans, animals and their natural environments. That brings together communities such as herders, health officials, human and veterinary doctors, ecologists, anthropologists and others.[882] Other new vehicles for cooperation provide spaces for diverse stakeholders to work together on creative, cross-sector innovation and decision-making.[883] Those highly replicable trials include Sustainable Development Goals labs,[884] transformation labs[885] or governance labs.[886]

3.3.2. Boosting capacity in the global South

Around 8 million researchers are now active worldwide, but the global distribution of this scientific capacity is highly unequal. The OECD countries have about 3,500 researchers per million inhabitants, 50 times the rate in the least developed countries, where there are only about 66 researchers per million inhabitants.[887] That low number of researchers, coupled with a lack of science tradition and funding and little access to published science, seriously hampers research systems in the global South. It also puts those countries at a disadvantage in negotiating and implementing the 2030 Agenda.

Least developed countries urgently need context-specific knowledge and support so as to break away from the historical association between economic development and environmental degradation, and instead build solid social foundations and environmental stewardship in tandem with economic development.

Existing knowledge on practical sustainability approaches and technologies should be systematically compiled and shared via open-access knowledge platforms. Least developed countries and small island developing states should have priority access to such resources, including scientific publications. But the data sources for these platforms should go beyond standard scientific research to include information from non-academic knowledge providers, such as government agencies, civil society organizations, the private sector, citizen-science initiatives and local communities. Key insights should be synthesized and translated into policy options and actions, supported by earmarked funding from official development assistance and international research programmes.

Fair scientific partnerships are essential for development. A recent initiative launched in sub-Saharan Africa, the Research Fairness Initiative, encourages governments, national research and innovation agencies, academic and research institutions, business and funders to report how they take measures to create fair partnerships in research and innovation for health that are trusting, lasting, transparent and more effective, and how they will plan towards improvement in key areas of the field.[888]

It is also important to invest in North-South and South-South research partnerships. Those can build transformative capacities and applications in developing and transition countries, as well as in the global North.[889] Various international donors and foundations have increased their funding for research cooperation (see box 3-7). However, more support is needed, some of which can come from domestic sources within developing and transition countries. The African Open Science Platform[890] provides a powerful example of African states' developing their own capacities towards usable interdisciplinary data collection for scientists and societal actors.

Box 3-7
Transboundary research partnerships[891]

Transboundary research partnerships with developing and transition countries have been around since the 1950s. A key feature of that partnership approach is collaboration with non-academic stakeholders throughout the knowledge-generation process. To realize mutual benefits and generate sound knowledge for sustainable development, successful research partnerships must observe certain key principles. Those include joint agenda setting, building trust, mutual learning, shared ownership and accountability to beneficiaries.[892]

Several countries, such as France and Canada, already invest significantly in research partnerships based on those principles. The Government of the United Kingdom has committed £1.5 billion to partnership-based development research covering the period from 2016 to 2021, on behalf of the 2030 Agenda. Finally, foundations such as the Welcome Trust, the Volkswagen Foundation, and the Bill and Melinda Gates Foundation are making considerable investments in research partnerships.

3.3.3. Advancing research in society

Science does not exist in isolation from society. Today, the credibility and legitimacy of science and technology is increasingly being questioned by high-profile political actors and constituencies, as well as corporations. Such actions sow generalized doubt about facts and evidence.

Scientists and engineers, too, have sometimes neglected the responsibilities of being accountable to society, failing to contribute their insights to pressing issues and political deliberations about the future we want. They may also conduct research and innovation that lacks societal accountability, strengthening the image of science as an ivory tower pursuit.

Sustainability requires freedom to conduct research explicitly in the interest of humanity in a spirit of stewardship of the environment and in consideration of the fundamental values of justice.[893] To that aim, researchers, engineers and the wider public should openly discuss and agree on the changing position of science and technology, its freedoms and constraints and its obligations. Ultimately, scientific freedom can be preserved only when its role in society is mutually deliberated, agreed and upheld.

People everywhere, especially the younger generations, are ready to tackle our shared sustainability challenges. There is, for example, growing support and political traction for climate action, changing consumer behaviours and environmental protection. Young scientists often play a central role in mobilizing those ideas through creative science and independent voices, facilitated by networks such as the Global Young Academy and the Major Group on Children and Youth.[894] By bringing together societal actors and non-academic knowledge providers committed to the 2030 Agenda, science can secure its position as an indispensable provider of valuable, trustworthy evidence and advice.

Chapter IV

Chapter IV

Call to action

It is clear that we need fundamental transformation in order to reach the sustainable future outlined in the 2030 Agenda, and our window for action is the next decade. We need all actors – government, the private sector, civil society, academia, communities and individuals – to work together, capitalizing on the critical interlinkages among the Sustainable Development Goals and taking bold, coordinated action to send the world along effective pathways to sustainable development.

As the Independent Group of Scientists appointed by the Secretary-General to prepare the first edition of the quadriennial Global Sustainable Development Report, we launch the following calls to action, covering each of the six entry points identified in this Report: strengthening human well-being and capabilities; shifting towards sustainable and just economies; building sustainable food systems and healthy nutrition patterns; achieving energy decarbonization with universal access to energy; promoting sustainable urban and peri-urban development; and securing the global environmental commons. In addition, we call for concrete actions to strengthen the science-policy interface to accelerate progress and transformation for sustainable development.

4.1. Strengthening human well-being and capabilities

The 2030 Agenda aims to secure human well-being, eradicating deprivations across multiple dimensions, closing opportunity gaps and expanding capabilities, while safeguarding the natural environment on which everyone depends. Pathways to advance human well-being ultimately require cooperation, collaboration and dialogue between multiple actors, and employing many levers of change. There is no single pathway, and there are different combinations of efforts required across regions and for countries in special situations. The result should be the same across contexts: no one should be left behind.

A1. All stakeholders should contribute to eliminate deprivations and build resilience across multiple dimensions through universal provision of, and access to quality basic services (health, education, water, sanitation, energy, disaster risk management, information and communications technology, adequate housing and social protection), that are universally accessible with targeted attention where poverty and vulnerability are concentrated and with special attention to individuals who are most likely to be left behind – women and girls, persons with disabilities, indigenous peoples and others.

- Measure poverty in multiple dimensions based on a country-level understanding of poverty (e.g., deprivations in education, health, food/nutrition, housing, social security and others); and use those measures to shape the development planning process and promote coordination among ministries.

- Promote universal social protection systems, financed through more progressive fiscal strategies where individual contributions are proportionate to income and revenues, to increase resilience in a world undergoing significant changes from climate

change, rapidly advancing technologies and the rise of informal work. Social protection, including pensions and support for older persons and persons with disabilities, should not be limited to those who spent their working years in formal, full-time jobs.

- Provide universal access to health care, with special attention paid to maternal health and prenatal care and child care, as well as comprehensive health care for women, and access to education, with special attention paid to early childhood education and the removal of barriers to girls at all levels of education. Additionally, user fees for access to public health care facilities should be removed or significantly limited, and out-of-pocket-payments for schooling should be reduced in order to significantly increase service use among the poorest population. Technology should be employed to increase access to health and education services for underserved populations and those with limited mobility.

- Increase investments in health and education services and infrastructure for water and sanitation, energy and telecommunications. Governments can increase public spending, but the private and not-for-profit sectors and civil society can also play a vital strategic role in increasing access, innovating new approaches to provisioning and removing barriers. Private business and public organizations can also contribute through improving services for employees and their families.

- Increase resilience to economic shocks and natural and man-made disasters. In addition to increasing social protection coverage, this can be done through active implementation of the Sendai Framework for Disaster Risk Reduction (2015–2030) with improved coordination with other landmark United Nations agreements like the Paris Agreement (United Nations Framework Convention on Climate Change, 2015) and the Habitat III New Urban Agenda (2016).

A2. Governments should ensure equal access to opportunities, end legal and social discrimination and invest in building human capabilities so that all people are empowered and equipped to shape their lives and bring about collective change.

- Strengthen the rule of law, enforce anti-discrimination laws and address discriminatory social norms to ensure universal and effective access to justice for all groups across countries, to improve equal access to opportunities and to reduce group inequalities including between women and men.

- Provide universal and equal access to quality services to enhance human capabilities. Innovate incentives to increase the numbers of service providers in health care and education, improve their qualifications, extend their presence and enhance their performance. Make available and encourage training in new technologies and techniques.

- Invest in early childhood development and support higher enrolment in science, technology, engineering and mathematics (STEM) programmes to build human capabilities with particular attention to gender inequalities. Increase research on and support services for mental health and non-communicable diseases.

- Unions, non-governmental organizations, women's groups and other community organizations provide a means for forming shared goals and pursuing them in the face of social inequalities. Those groups need to have the freedom to organize, as well as have optimal access to information and knowledge, thus boosting their capabilities to contribute to the sustainability transformation at various levels.

- Ensure refugees and forcibly displaced people are counted and made visible in activities related to the Sustainable Development Goals. Promote accelerated action in favour of fragile States and conflict-affected populations. Include people caught in crisis in national development plans and strategies of the Goals.

4.2. Shifting towards sustainable and just economies

Growth needs to be decoupled from environmental degradation by using different approaches in low- and high-income countries. That requires environmentally sustainable development, combined with the new elements of a circular economy. All countries should promote upward convergence in living standards and opportunities, accompanied by reduced inequalities in wealth and income.

A3. Governments, international organizations and the private sector should work to encourage investment that is more strongly aligned to longer-term sustainability pathways and to facilitate disinvestment away from those that are less sustainable.

- The United Nations and other organizations should promote a new sustainable development investment label to provide a technically robust system that defines what sustainable means and help to channel capital flows towards assets that contribute to sustainable development.

- The United Nations and other organizations should promote measures other than GDP that

reflect a more comprehensive assessment of overall national well-being.

- Governments and other stakeholders should ensure suitable and just transitions for those losing work owing to disinvestment.

A4. All stakeholders should work together to achieve a global decoupling of GDP growth from the overuse of environmental resources, with different starting points that require different approaches across rich, middle-income and poor countries.

- Attain higher levels of growth in poorer countries, with effective universal provision of quality services and transition to environmentally sustainable development paths, including through access to appropriate technologies and knowledge.

- Build support for and implement coherent tax and subsidy policies that accelerate the transition to sustainable development.

- Encourage changes in patterns of demand and consumption, including through regulation, promotion of sustainable advertising and marketing practices, and consumer education, to reduce environmental impact.

- Promote the transition towards a circular economy, including waste management and planning approaches that emphasize waste prevention as opposed to end-of-pipe waste management.

- Limit use of plastics and their presence in the environment through government regulation and multi-stakeholder engagement along the value chain.

- End the export of e-waste and hazardous chemicals to countries that do not have the advanced infrastructure to manage them.

A5. Governments, supported by civil society and the private sector, should promote an upward convergence in living standards and opportunities, accompanied by reduced inequalities in wealth and income, within and across countries.

- Strengthen the returns to work to achieve a more equitable balance with the returns to capital and ensure full parity across genders.

- Apply redistributive strategies appropriate to context to reduce inequality, with additional targets for the most severe inequality dimensions in each country. Report on those targets in voluntary national reviews.

- Proactively assess and deploy new technologies to ensure that they reduce inequalities in wealth, income and opportunities rather than increase them.

- Ensure global cooperation on tax policy to eliminate diversion and tax avoidance.

- Promote the standardization and adoption of alternative measures to GDP that better account for human well-being, environmental and social impacts.

- Encourage governments, with the support of the private sector and civil society, to explore equitable employment opportunities for workers displaced in the shift to the low-carbon economy.

4.3. Building sustainable food systems and healthy nutrition patterns

Leaving no one behind requires a focus on more equitable access to nutritional foods, including through substantial changes to the existing food system infrastructure and attention to relative prices. Improvements in global nutrition must be accompanied by a reduction in the environmental impact of food systems and an increase in food system resilience to climate change and other potential disrupters, including political instability and conflict.

A6. All stakeholders should work to make substantial changes to existing infrastructure, policies, regulations, norms, and preferences so as to transition towards food and nutrition systems that foster universal good health and eliminate malnutrition while minimizing environmental impact.

- Every country should use advocacy, education, regulation and guidelines to promote food that meets nutritional and environmental standards, taking into consideration context and local cultures, traditions and diets.

- Governments should establish stronger social-protection floors to enhance food security and ensure adequate caloric intake and the quality of diets, with special attention to the needs of women and girls. Innovative insurance mechanisms can be part of such floors. Special attention and support are needed in least developed countries.

- Promote agroforestry to increase forestation, decrease soil erosion and strengthen resilience by diversifying income, particularly in developing countries.

- Discourage excess usage of fertilizers in agricultural production, especially those releasing nitrogn and phosphorus into environment, which can be done through regulation and through

deployment of new technologies. Reuse of nutrients and energy on farms should also be encouraged.

- Establish and enforce quotas on fisheries, ensuring the access of small-scale fishers and fish producers.

- Scale up reliance on agroecology as a means to sustainably intensify food production and to accelerate the transition towards a synthetic pesticide–free agriculture. This requires a reassessment of production practices, with the least possible pesticide use and no critical residues in plants and foodstuffs.

- Diversify species and genetic resources in the agroecosystems over time and space, from the field to landscape levels, and focus on interactions and productivity across the agricultural system rather than focusing on individual species.

- Invest in more environmentally friendly and technologically advanced meat production and ensure more equitable access to meat as a food source, with significant reductions in meat consumption where current rates are high.

- Transform consumer awareness of, demand for, and access to affordable, sustainable and nutritious diets and strengthen the enabling environment to promote and catalyse greater and more responsible business investment in good nutrition. Special attention is needed toward eliminating malnutrition, as well as reducing obesity and overweight and the incidence of noncommunicable diseases.

- Build a global surveillance system for crop diseases in order to improve international and national responses to plant-disease outbreaks.

A7. Countries must take responsibility for the entire value chain related to their food consumption so as to improve quality, build resilience and reduce environmental impact, with developed countries supporting sustainable agricultural growth in developing countries.

- The international community should support sustainable development of agriculture in developing countries, including through inclusive business models in agriculture and promotion and transfer of existing sustainable technologies.

- Ensure that labelling on imported food clearly indicates production origins and conditions surrounding production. New information technologies can enable that.

- All countries must try to reduce dependence on foods and food production methods that entail high water demand. In order to secure national, long-term food security, data on water flows through food importation should be recorded.

- National policies should be established to build up food reserves, while keeping stable and fair prices on food.

- Governments should support domestic food producers to reduce their environmental footprint.

- Work to reduce food waste through the regulation of packing, transportation, expiration dates and waste practices in food-service industries.

- Trading systems and trade agreements should facilitate the realization of the objectives of universal access to nutritious food at sustainable environmental costs.

- Strengthen the agri-food value chains and pro-poor markets for nutritious foods, including through naturally nutrient-dense foods (e.g., fruits, vegetables, pulses, animal source foods and nuts) and through biofortified and fortified staple foods.

4.4. Achieving energy decarbonization with universal access to energy

Strategies for transforming the energy sector must use all available tools to promote accessible and decarbonized energy, including through rapid scale-up of renewable energy, modernization of electricity transport and distribution, increased energy efficiency and electrification of energy end-uses.

A8. All stakeholders must ensure universal access to affordable, reliable and modern energy services through the accelerated implementation of cost-efficient provision of clean electricity, coupled with making clean-cooking solutions a top political priority, and moving away from using traditional biomass for cooking. All stakeholders should promote clean, reliable and modern energy sources, including by harnessing the potential of decentralized renewable energy solutions.

- All governments and local authorities need to establish detailed plans of action to close the electricity access gap, backed by determined leadership, targeted policies and regulations, multi-stakeholder partnerships and increased investments in both on- and off-grid solutions.

- Depending on country circumstances, integrate cross-border grid connections, renewable energy solutions and decentralized options into action strategies.

- Prioritize the adoption of clean-cooking solutions, replacing biomass usage with cleaner alternatives for cooking.

A9. International and national entities and stakeholders must collaborate to reshape the global energy system so that it participates fully towards the implementation of Goal 7 by transitioning to net-zero CO_2 emissions by mid-century, so as to meet the goals of the Paris Agreement including by introducing carbon pricing and phasing out fossil fuel subsidies.

- Scale up investments in energy efficiency across all sectors of the economy and support them with evidence-based tools and policies.
- Introduce carbon pricing, which is essential to shift energy systems towards the net-zero target by 2050. Ensure the fair usage of the revenues collected, including to fund the energy transition and offset additional costs for the poor.
- Commit to the full transition away from internal combustion engine vehicles to cleaner alternatives, such as electric public transport and shared electric vehicles
- Phase out fossil-based power generation without carbon capture and storage by 2050, targeting coal power plants first, as they are important sources of CO_2 and other pollutants.
- Discourage new investments in coal, oil and gas exploration, as they risk leading to stranded assets.
- Phase out direct and indirect fossil fuel subsidies by 2025 in developed countries and by 2030 in developing countries. The funds previously used as subsidies should be reoriented towards affordable renewable energy and energy efficiency particularly for the poor.
- Strongly accelerate the pace of transition towards renewable energy, especially in end-use sectors such as transport, buildings and industry.
- Governments need to promote public and private investments and international cooperation for research, development, deployment and diffusion of changes to the energy system that will address Goal 7 and the decarbonization challenge related to the 1.5°C target.
- Direct climate finance and other public finance, as well as shape trade agreements, in ways that will promote maximum synergies between the 2030 Agenda and the Paris Agreement.
- All stakeholders should pay special attention to the interlinkages between energy and poverty eradication, reduction of inequalities, gender equality, jobs, biodiversity and climate change.

4.5. Promoting sustainable urban and peri-urban development

Priorities should be people-centred and pro-poor policies and investments for liveable cities. Cities should have the tools to engage in effective, evidence-based and inclusive participatory policymaking.

A10. National governments should give cities the autonomy and resources to engage in effective, evidence-based and inclusive participatory policymaking with an engaged and informed citizenry.

- Promote a decentralization principle so that city governments and communities retain the maximum possible authority and autonomy in policy, service provision and budget matters.
- Invest in institutions that are developing a new "science of cities" and in partnerships among city mayors, particularly between cities in developed and developing countries, and among small and medium-sized cities.
- Increase support to and investment in medium-sized cities and promote polycentric urban development.

A11. National governments and local city authorities, in close collaboration with the private sector, should promote people-centred and pro-poor policies and investments for a liveable city that provides decent, sustainable jobs, sustainable universal access to vital services such as water, transport, energy and sanitation, with effective management of all waste and pollutants. Individuals and communities should also scale up their engagement in advancing sustainable urban development.

- Invest in decent and sustainable jobs, including those enabled by technology and nature-based industries;
- Expand investment in sustainable infrastructure, water and sanitation and other services and "smart city" technologies, including, where workable and mutually beneficial, through public-private partnerships;
- Increase investment in innovative and effective approaches to address waste and air pollution in cities and surrounding peri-urban and rural areas;
- Promote sustainable consumption and production patterns through well-planned land use, rapid scale-up of renewable energy and energy efficiency, and effective sustainable urban mobility plans, with fewer cars and more public transit and active mobility options, with an emphasis on accessibility for all;

- Scale up efforts to build urban resilience, especially of coastal cities and civil infrastructure, including through nature-based solutions;
- Ensure that urban planning prioritizes those at risk of being left behind, including those in informal settlements and persons with disabilities;
- Foster urban citizens' relationship with nature by promoting green space, urban biodiversity and urban food production, and encourage cities to strengthen ties with their surrounding peri-urban and rural areas;
- Invest in programmes to create an active citizen base, encouraging collective action and partnerships to change behaviour and advance social cohesion and sustainable lifestyle choices.

4.6. Securing the global environmental commons

The world is largely off track in terms of sustainable use of natural resources, and all actors must work in an ambitious and coordinated manner to safeguard the global environmental commons, including the large-scale biomes and systems that contribute directly or indirectly to the functioning of the Earth system and hence to supporting life, including biodiversity, the atmosphere, oceans, the cryosphere, forests and the hydrosphere.

A12. Governments, local communities, the private sector and international actors must urgently achieve the necessary transformations for conserving, restoring and sustainably using natural resources while simultaneously achieving the Sustainable Development Goals.

- To improve control of air pollution, cities must improve the quality of fuels used in vehicles and offer greener, safer and higher-quality means of public transportation for commuters in big cities. Open fires of biomass, plastics and waste should be regulated.
- Governments should adhere to and fulfil their commitments to multilateral agreements which aim to secure global environmental commons (particularly the United Nations Framework Convention on Climate Change, the Convention on Biodiversity and the United Nations Convention to Combat Desertification), and explore new multilateral agreements to guarantee the protection of the largest tropical rainforests of the planet (in Africa, Asia and South America) and extend marine protected areas to at least one third of the ocean by 2030. Governments should continue to work for the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction.
- Expand and effectively manage the current network of protected areas (terrestrial, freshwater and marine) through adaptive governance, strong societal engagement, effective and equitable benefit-sharing mechanisms, sustained funding, and monitoring and enforcement of rules.
- Engage in cross-sectoral and sector-specific interventions and integrated water resources management at all levels to sustain fresh water in the context of climate change, rising demand for water extraction and increased levels of pollution.
- Governments should work with farmers, industry and academia to develop and implement sustainable irrigation or water harvesting schemes, increase the efficiency of water use for major crops and livestock and boost the recycling and reuse of water. They should explore the cultivation of more drought-tolerant crops, expand crop insurance schemes and support alternative livelihoods that can provide income in drought-prone areas.
- Protecting oceans must include governance towards sustainable planning for coastal areas and regulations on pollution of rivers.
- National governments should work with scientists and fishers to increase the number of sustainable fisheries within their exclusive economic zones. Governments should work with each other, scientists and fishers regionally and internationally to consider how fishing outside of exclusive economic zones should be managed at sustainable levels or eliminated. They should also take steps to eliminate illegal fishing by their citizens and corporate entities within the exclusive economic zones of other countries.
- Governments should take immediate action to support land degradation neutrality so as to benefit food security, biodiversity and farmers' livelihoods and mitigate climate change. The transition to sustainable land-management practices, requires sectoral coordination and investments in integrated land-use planning. An evidence-based framework for accounting for carbon debits and credits are essential for measuring progress. Future carbon accounting frameworks need to cover all land uses and land-use changes so that the land-use sector's mitigation contribution can be properly recognized.
- Halting deforestation remains one of the most efficient "bouquet" measures to achieve numerous goals in biodiversity, improving the well-being of people whose livelihoods depend on forests, water and soil conservation, and mitigating climate change. Actors should include civil society, communities (including indigenous peoples) and governments. Responsible production, minimizing

damage and integrating the cost of damage into business plans should also guide forest owners and businesses using forestland. Responsible consumption and awareness and better traceability of products is key for a societal vision for the protection of forests and to reduce deforestation.

- National Governments should work with each other to increase the use of remote sensing and other technology to monitor and manage the state of forests and other vital ecosystems, such as watersheds and the coastal zone in developing countries. That may include policies to share satellite imagery and other technological data and to work with academia to build in-country capacity for analysis.

- Early warning systems for drought, floods and other extreme meteorological events, combining remote sensing with field data collection, could guide vulnerable countries by providing timely information that they can use to build resilience, reduce risks and prepare more effective responses. Better forecasts should be combined with vulnerability and assessments of how landscapes and societies respond to those events.

A13. Governments must accurately assess environmental externalities – in particular those that affect the global environmental commons – and change patterns of use through pricing, transfers, regulation and other instruments.

- National, regional and local authorities should encourage and support the development and use of standards, metrics and methods for quantifying, reporting and managing natural capital risks and opportunities. They should adopt a long-term horizon, taking account of how technological developments and existing environmental regulatory provisions might evolve.

- Governments should work with companies that depend on or affect natural capital to ensure they manage the related risks, including supply-chain disruption and other operational, reputational, production, legal and regulatory, human rights and health risks.

- Financial institutions should ensure that, at the very least, they do no harm and do not support companies that deplete natural capital. Financial risk management should treat natural capital as an integrated whole, not as a series of stand-alone components. Climate change, water, biodiversity and public health are interrelated, and those links should be analysed to ensure no risks are missed.

4.7. Science and technology for sustainable development

Scientific evidence is a prerequisite for designing and implementing transformations to sustainable development. Given the urgency to act, the 2030 Agenda can serve as a shared compass to rapidly mobilize and harness the extensive knowledge available. Many low- and middle-income countries need to design and pursue development that breaks the path of Western-style path dependence of economic growth at environmental costs.

A14. Stakeholders must work with the academic community in all disciplines to mobilize, harness and disseminate existing knowledge to accelerate the implementation of the Sustainable Development Goals.

- Member States should support international scientific assessments and similar global programmes that crystallize areas of scientific consensus and broker knowledge to decision makers, and establish a platform related to the United Nations to synthesize knowledge, share best practices in implementation of the Sustainable Development Goals and provide continuous support for assessment of the 2030 Agenda and future editions of the Global Sustainable Development Report. Increasing attention should be paid to regional perspectives, understanding how change is possible and maximizing coherency and synergies between such assessments.

- Member states should establish regional and national knowledge platforms as part of a globally coordinated, systematic effort to collect, synthesize and translate scientific evidence with a view to steering interactions among the Sustainable Development Goals towards country-specific pathways to sustainable development.

- Governments at various levels should form sustainable development councils that comprise panels of diverse experts, including scientists, in an effort to valorize available evidence and strengthen knowledge diplomacy.

- The scientific community should develop new strategies and skills for collaboratively engaging with civil society, the public sector and businesses in order to pool available knowledge and align research agendas towards implementation of the 2030 Agenda.

A15. Governments, research consortiums, universities, libraries and other stakeholders must work to enhance the current levels of access to knowledge and disaggregated data, as well as scientific capacity and good-quality higher education, in low- and middle-income countries and countries in special development situations. They must also actively promote gender equality in science and engineering.

- Member States, research consortiums and libraries should work together to remove the barriers to published scientific knowledge and data. A more coordinated, harmonized international effort is urgently needed to enable open access to published research. It should prioritize low-income countries and institutions that cannot afford subscriptions or article processing fees and lack the clout to negotiate better deals. Major gains could be immediately realized by unlocking humanity's intellectual commons.

- Member States, funding organizations and academic communities should actively promote gender equality in science and engineering

- Member States and research consortiums should work together to increase the amount and coverage of technological data (e.g., satellite imagery) that is freely available, especially to developing countries in as many cases as possible.

- Overseas development aid budgets should prioritize boosting scientific capacity and access in the global South. Key concrete measures include establishing comprehensive, open-access knowledge platforms on the Sustainable Development Goals; maximizing existing research capacity and cultivating future potential; and building institutions to coordinate research on behalf of implementation, monitoring and evaluation of the Goals.

- Research funders should recognize and strongly support long-term North-South and South-South research partnerships as an effective means of tackling the acute social and ecological challenges faced by low- and middle-income countries.

- International organizations, governments, and academic institutions should strive to stem "brain drain" from developing countries, and instead support ongoing "brain circulation". Promoting continuous circular flows within the international scientific community would boost capacities and expertise in low- and middle-income countries and within high-income countries as well.

- To the extent possible, low- and middle-income countries should facilitate high-quality education in sustainable development in their schools and universities.

- Backed by the global community, low- and middle-income countries should strive to build their own national and regional funding institutions for scientific research.

A16. Universities, policymakers and research funders must scale up support to mission-oriented research, guided by the 2030 Agenda, in sustainability science and other disciplines, with simultaneous strengthening of the science-policy-society interface.

- Building on national knowledge platforms, the United Nations should launch a major scientific assessment of existing transformation knowledge from both scientific and non-scientific sources, including lay, practical and indigenous knowledge.

- National and international science policymakers and public and private funding institutions should rapidly increase their support for mission-oriented research – guided by the 2030 Agenda – in both relative and absolute terms. Meeting today's sustainability challenges and overcoming vested interests requires unprecedented levels of funding, from both public and private sources.

- Science funders should adapt their schemes to support broader programme structures that enable long-term, collective efforts by wider research consortiums. That will encourage sustainability science that employs the interdisciplinary and transdisciplinary approaches needed to tackle the complex, contested issues and trade-offs inherent to sustainable development.

- Research institutions such as universities, academies and scientific associations should expand their evaluation systems to recognize interdisciplinary and transdisciplinary skills, and reward research that strives for societal relevance and impacts. Instituting the right incentives is crucial to fostering the careers of up-and-coming sustainability scientists. Senior researchers should support and encourage their students and younger colleagues to carry out sustainability science and to engage fully in communicating it to an outside audience.

- Universities should fully embrace the mission of advancing sustainable societies by promoting education for sustainable development. Building the capacities and skills of the next generation of researchers and change makers is one of the biggest leverage points towards sustainability at humanity's disposal.

- Public, private and philanthropic donors should nurture experimental spaces for collaboration on transformation pathways. Taking science-policy-society interfaces to the next

level, those spaces can cultivate new partnerships and foster co-creation, testing and extension of transformational ideas.

A17. All stakeholders should make deliberate efforts to facilitate multidirectional (North-South, South-North and South-South) transfers of technologies for achieving the Sustainable Development Goals.

- Increased efforts should be devoted to operationalize the technology facilitation mechanism related to the Sustainable Development Goals to facilitate the dissemination of environmentally sound and frugal technologies.

- Technologies essential for the sustainability transition and climate change action should be made available under flexible terms to developing countries, and those countries' capacities for putting them to use should be enhanced.

- Member States should follow the principles of the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization which was introduced in 2010 as a supplementary agreement to the 1992 Convention on Biological Diversity,[895] and all should introduce practical mechanisms for its application in their own legal and regulatory systems.

- Both public and private sectors should collaborate to promote open-source innovations with types of licences for computer software and other products that allow the source code, blueprint or design that can be used, modified and/or shared under defined terms and conditions and is made mostly available free of charge.

- Artificial intelligence international, regional and national standards should allow for data to flow fairly and freely across borders so as to guarantee interoperability. In order to foster public trust in artificial intelligence systems, regulations and codes of conduct should strike a proper balance between technological progress and people's right to privacy and human dignity.

- Accessibility and the principles of universal design should be part of curricula in design, computer science, user experience and other relevant subjects, as well as mainstreamed in industry settings. That will create environments where the goods and services developed are usable and accessible to the greatest number of people possible.

4.8. Not incremental change but transformation

Science has shown that we are on an unsustainable path that is destroying the natural world on which we depend for survival. Science has also indicated that the outcome is not inevitable. Guided by the Sustainable Development Goals, governments and other national and international organizations are already working with civil society and academia to illuminate more productive sustainable paths that will enable future generations to live within the limits of the Earth system.

The need is critical, and action must be bold and decisive, not just for change but for systemic transformation.

A18. Multilateral organizations, governments and public authorities should explicitly adopt the Sustainable Development Goals as a guiding framework for their programming, planning and budgetary procedures. To accelerate the implementation of the 2030 Agenda, they should devote special attention to directing resources – including finances, official development assistance at levels that meet international commitments, and technologies – to the six entry points, applying knowledge of the interlinkages across Goals and targets, contributing to the co-benefits and resolving trade-offs. The United Nations and other international and regional organizations should facilitate exchange of information and disseminations of lessons learned on the use of the Sustainable Development Goals framework among countries.

- All stakeholders should work together towards deep transformative changes in the six entry points presented in this report, namely human well-being and capabilities, sustainable and just economies, sustainable foods systems and nutrition patterns, energy decarbonization with universal access to energy, sustainable urban peri-urban development and the global environmental commons. They should work towards coherence in policy and budgetary decisions to advance change.

- Stakeholders should recognize and leverage the interactions among the Goals in order to resolve the essential trade-offs hindering progress and to harness co-benefits among Goals.

- Governments must ensure that trade-offs between the Goals are resolved and thus conflicts of interests between different sectors and administrative levels are addressed through the necessary political processes.

- Multilateral organizations, governments and public authorities should adopt the Goals as the explicit mandatory framework for their programming, planning and budgetary procedures. They should devote special attention to assessing how policies targeted towards one Goal impact all the other Goals.

- Member States should also establish mechanisms to improve and monitor policy coherence for sustainable development to harness the multiple co-benefits, increase effectiveness and save costs in implementing the Goals.

- The United Nations and other regional and international organizations should facilitate regular exchange of information, best practices and lessons learned between countries on working with interactions among the Goals through the six systemic entry points.

A19. The four levers of change – governance, economy and finance, individual and collective action, and science and technology – should be coherently deployed and combined to bring about transformational change. All actors should strive for coordinated efforts and prioritize policy coherence and consistency across sectors.

- The four levers are a powerful agents of change that can impact the world for better or for worse. The 2030 Agenda must therefore be used by all stakeholders as guidance and as a normative reference to the deployment of those levers, and as a criterion for evaluating their performance.

- Development finance institutions, that is, all public development banks – national, regional and multilateral – as well as business and private finance sectors, should put the onus on investors to take account of sustainability when making investment decisions or engaging with investees on their portfolios. Through regulatory and behavioural changes, market practices should better reflect the need to orient financial flows towards sustainable development and adopt sustainability standards.

- Transformation is possible only when the levers are deployed together in an integrated and intentional manner. The key innovation needed to advance the implementation of the 2030 Agenda must come from novel combinations of levers. Actors from governance, economy and finance, civil society, and science and technology must thus rethink their partnership and establish novel collaborations.

A20. Every country and region should design and rapidly implement integrated pathways to sustainable development that correspond to the specific needs and priorities, and which contribute also to the necessary global transformation.

- For each of the six entry points, Member States and regions need to understand the specific challenges and impediments and the needs and priorities they have. That shall inform the combination of levers and the collaboration of actors needed to pursue an integrative pathway to sustainable development in the six entry points.

- Although each country faces diverging challenges and has different priorities, as of today all countries must start to pursue such innovative pathways to reconfigure people-nature relations determining the success of the Sustainable Development Goals. Growing first and cleaning up later is not an option in terms of both a country's own interest of not falling behind and the need for achieving transformations universally.

- Flows of goods, capital, information and people connect the countries in a way the world has never known before. That implies that each pathway that an individual country pursues may produce negative spillover effects on other countries, but the success of the pathway may depend on those countries. Multilateral collaborations, agreements and policies are thus essential and need to be strengthened.

Afterword

Afterword

With the submission of the Global Sustainable Development Report to the United Nations Sustainable Development Goals Summit in September 2019, the task assigned to this first Independent Group of Scientists in the mandate by United Nations Member States, comes to an end. According to that mandate, an outcome of the 2016 High-level Political Forum on Sustainable Development, the Report should incorporate the different strands of scientific knowledge to provide an integrated assessment of and guidance on the state of global sustainable development and, at the same time, strengthen the science-policy interface and put forward scientific evidence to support a wide range of stakeholders in different regions and countries in the implementation of the 2030 Agenda.

The Independent Group of Scientists comprised 15 experts, women and men, from geographical regions, representing a variety of backgrounds, scientific disciplines and institutions. In taking up our mandate as such a heterogeneous group in early 2017, we agreed that we needed to go beyond simply designing a process to ensure the inclusion of perspectives from different scientific and policy fields, encompassing actors in different sectors and varied geographic regions. We also agreed that the spirit of the 2030 Agenda and its overarching goal to advance human well-being in an equitable and just fashion should guide our deliberations and our work.

Facilitated by the United Nations Department of Economic and Social Affairs (UNDESA), the Group met many times, both face-to-face and virtually, with consistent support from a task team of six United Nations offices and entities.* Its work benefited from over 300 contributions received through an open call for inputs; six regional and cross-disciplinary consultation workshops; regular briefings with and comments from Member States and other stakeholders; and reviews of advance drafts by some 100 scientists

The mandate given by the Member States defined the scope of the report, and our analyses led us to three essential insights. First, although our integrated "assessment of assessments" shows that we are not on track to reach many Sustainable Development Goal targets – and not even progressing in the right direction, in several cases – there is enough scientific knowledge to indicate the ways forward. The evidence clearly shows that accelerated results over the next 10 years are possible, but only through an approach that builds on a truly systemic understanding of the indivisible and universal 2030 Agenda for Sustainable Development. Only if we intentionally address the inherent trade-offs among the Goals and harness the abundant co-benefits, will we be able to multiply and scale-up the transformations that we urgently need. The report identifies six key entry points in that regard.

Second, we consider governance, business and finance, individual and collective behaviour, and science and technology to be crucial levers for transforming vicious into virtuous circles. However, diverging values and interests of powerful actors still hinder the achievement of the Agenda and make it difficult to take the intentional and integrated

* Department of Economic and Social Affairs, United Nations Environment Programme (UNEP), United Nations Conference on Trade and development (UNCTAD), United Nations Development Programme (UNDP), United Nations Education, Scientific and Cultural Organization (UNESCO) and the World Bank.

actions that are necessary. Sustainable development will therefore not be attained automatically as a fair compromise across all actors. To achieve the needed transformations in a narrow window of time, and in a world that is increasingly hyper-connected across sectors and national boundaries, hard choices will need to be made. This requires strong political leadership and novel collaborations with governments, business, finance, civil society and academia.

Third, the success of the 2030 Agenda will depend on implementation at the country level, as well as international collaboration. The most useful knowledge is context specific, and specific challenges, needs and priorities also differ across countries. There will be many distinct pathways to sustainable development worldwide. Yet, all countries share the same challenge of reconfiguring the relationship between people and nature and the need to embark on such pathways now rather than later. International collaborations and partnerships are essential components of this effort.

The title of this report – *The future is now: science for achieving sustainable development* – expresses its central message. It points to the ultimate challenge we have identified in it: in order to secure the future of humanity and the planet we cannot wait for crises – with potentially irreversible and unmanageable consequences – to trigger change. Rather, we need to act now based on our current knowledge and understanding.

The report clearly shows that such transformations are possible, and that sufficient knowledge is available to get started. However, we need to overcome the gap between what we know and what is being done. We strongly believe that scientific evidence must contribute to triggering the social and political debates about the hard choices that need to be made, and to formulating effective policies for the necessary transformations.

At the same time, it is equally important to recognize that the values and the spirit of the 2030 Agenda must guide the contributions of science in these critical times to help address knowledge gaps, and find innovative solutions. In order to meet the transformational challenges of the next decade, we need agree on a global mission to achieve universally accessible and mutually beneficial sustainability science.

Looking back at the preparation process for this first quadrennial Global Sustainable Development Report, we wish to acknowledge and thank the Member States for the mandate, and the Secretary-General for appointing the Group to draft the report. We are humbled by the Member States' confidence and their trust in our findings. We hope that we have been able to establish a solid foundation on which the next independent group of scientists can continue and deepen scientific contributions towards achieving sustainable development.

As co-Chairs of the Group, we are deeply appreciative of the enthusiasm, dedication and professional contributions of all the members of the Group, the support teams in their home institutions, and the governments that provided financial backing. We would particularly like to thank the staff of UNDESA, in particular Shantanu Mukherjee, Stephanie Rambler, Astra Bonini and Maria Godunova, for the extraordinary work and innumerable tasks performed in supporting the coordination, preparation, drafting, publication, release and communication of the Report.

We also wish to acknowledge and thank the individual members of the Task Team, the numerous stakeholders from all fields who participated in our consultation workshops around the world, as well as the International Science Council (ISC), the InterAcademy Partnership (IAP), and the World Federation of Engineering Organizations (WFEO) for coordinating the review by experts and supporting our findings. Finally, we highly appreciated the comments from Member States and accredited stakeholders on an earlier draft of the Report. We trust that our "call to action" will motivate what is needed in order to realize our common future that is envisioned in the 2030 Agenda for Sustainable Development.

Peter Messerli

Endah Murniningtyas

Co-Chairs of the Independent Group of Scientists 2019

Notes

Notes

Chapter I: The transformative power of sustainable development notes (1-119)

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[36] United Nations Environment Programme (UNEP), 2019b); IPBES, 2018; IPCC, 2018; United Nations Convention to Combat Desertification (UNCCD), 2017.

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[38] The 2018 Multidimensional Poverty Index, covering 105 countries, indicates that 1.3 billion people live in households with overlapping deprivations in health, education and living standards. The overlapping deprivations are also disproportionately concentrated among certain groups – 1.1 billion of the multidimensionally poor live in rural areas and almost half are children. Women, older people, ethnic and racial minorities, certain religious groups, indigenous peoples, persons with disabilities, children and other marginalized groups fall below the population average in many contexts across measures of well-being. (Oxford Poverty and Human Development Initiative, 2018.)

[39] Ibid; Bourguignon and Morrisson, 2002.

[40] World Bank, 2018b.

[41] Center for Global Development, 2017.

[42] Kenny and Snyder, 2017.

[43] UNEP, 2019c.

[44] The study found that the ROW region would attain the sustainable consumption and production goal.

[45] DNV-GL, 2019.

[46] Nicolai et al., 2015.

[47] Sachs et al., 2019.

[48] Steffen et al., 2018.

[49] United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and the Small Island Developing States, 2013, 2015, 2017.

[50] United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and the Small Island Developing States, 2018.

[51] United Nations, Economic and Social Council (ECOSOC), 2019.

[52] United Nations Development Programme (UNDP), Africa, 2017.

[53] Sustainable Development Goals Center for Africa and Sustainable Development Solutions Network, 2018.

[54] ECOSOC, 2019.

[55] United Nations Economic and Social Commission for Western Asia (ESCWA), 2018.

[56] UNDP, 2018.

[57] ECOSOC, 2019.

[58] Ibid.

[59] Asian Development Bank, 2017.

[60] ECOSOC, 2019.

[61] United Nations Economic Commission for Europe (ECE), 2019.

[62] ECOSOC, 2019

[63] World Health Organization (WHO), 2019e.

[64] International Labour Organization (ILO), 2017a.

[65] United Nations, 2018b.

[66] UNDP, 2018.

[67] United Nations, 2018b.

[68] WHO and the World Bank, 2011.

[69] WHO, 2019.

[70] United Nations, 2009.

[71] Alvaredo et al., 2018.

[72] Ibid.

[73] Ibid.

[74] Autor, 2019.

[75] Bivens et al., 2014.

[76] Alvaredo, et al., 2018.

[77] UNDESA, 2019b.

[78] Corak presents this relationship for a group of rich countries, in a relationship referred to as "The Great Gatsby Curve" (Krueger, 2012), whereby increasing inequalities in income are accompanied by decreasing levels of mobility. The curve shows that, as inequalities increase, so does social immobility. Evidence to that effect is also presented by Chetty et al. (2016), who found that the proportion of American 30-year-olds who earned more than their parents at the same age (adjusted for inflation) was as high as nine in ten in 1970, but fell to less than half in 2014; a period over which income inequality

in the country also rose. (Corak, 2011; Corak, 2013; Chetty et al., 2016.)

79 Corak, 2016.

80 Krueger, 2012.

81 Corak, 2011.

82 Corak, 2013.

83 Ostry et al., 2014.

84 Marmot et al., 2012.

85 Sapolsky, 2018.

86 Boyce, 2018.

87 Cushing, et. al, 2015.

88 Chancel and Piketty, 2015

89 UNEP, 2019b.

90 IPCC, 2018.

91 Ibid.

92 Ibid., Table 5.1.

93 Water scarcity already affects every continent. Around 1.2 billion people, or almost one fifth of the world's population, live in areas of physical scarcity, and 500 million people are approaching this situation. (Molden, ed., 2007)

94 Climatetracker.org.

95 IPCC, 2018.

96 Weindl et al., 2017.

97 Geyer et al., 2017.

98 Ibid.

99 UNEP, 2018b.

100 Ibid.; UNEP, 2019.

101 McKinsey & Company, 2018.

102 Ritchie and Roser, 2018.

103 Baldé et al., 2017.

104 Ibid.

105 Ibid.

106 UNEP, 2018b.

107 Ibid.

108 Baldé et. al., 2017.

109 Ibid.

110 Grace et.al., 2016.

111 IPBES, 2019.

112 Ibid.

113 Ibid.

114 Raworth, 2012.

115 O'Neill et al., 2018.

116 Social thresholds are assessed with respect to the following indicators: life satisfaction, healthy life expectancy, nutrition, sanitation, income, access to energy, education, social support, democratic quality, equality and employment. Biophysical boundaries are assessed on a per capita basis relative to currently established limits (e.g., a 2°C limit to global warming) and include the following indicators: CO_2 emissions, phosphorus, nitrogen, blue water, eHANPP, ecological footprint and material footprint.

117 Dearing et al., 2014.

118 These thresholds include indicators corresponding to life satisfaction, healthy life expectancy, nutrition, sanitation, income, access to energy, education, social support, democratic quality, equality and employment.

119 O'Neill et al., 2018.

Chapter II: Transformations towards sustainable development notes (120-797)

120 Biermann et al., 2017.

121 Ibid.

122 UNEP, 2019b.

123 Breuer et al., 2019; Collste et al., 2017; Nilsson et al., 2016; O'Connor et al., 2016.

124 UNEP, 2019b.

125 Addison et al., 2018.; Asadullah and Savoia, 2018; Nnadozie et al., 2017.

126 ECOSOC, 2019.

127 Biermann et al., 2017.

128 Jordan et al., 2018; Bulkeley et al., 2014; Pattberg and Widerberg, 2015.

129 World Bank, 2017c.

130 UNEP, 2019b.

131 World Economic Forum, 2019.

132 Ibid.

133 Pattberg et al., 2019.

134 Hsu, 2016.

135 Bäckstrand and Kylsäter, 2014.

136 Leach et al., 2012.

137 Boas et al., 2016; Biermann et al., 2017; Leach et al., 2018.

138 Leininger et al., 2019.

139 World Bank, 2016.

140 Shimeles and Nabassaga, 2017.

141 Coppedge et al., 2018.

142 V-Dem Institute, 2018.

143 Ibid.

[144] Ibid.

[145] Ibid.

[146] World Trade Organization (WTO), 2017.

[147] United Nations, Inter-agency Task Force on Financing for Development, 2019.

[148] International Monetary Fund (IMF), 2019.

[149] United Nations Conference on Trade and Development (UNCTAD), 2014.

[150] Gaspar et al., 2018.

[151] Schmidt-Traub, 2015.

[152] Gaspar et al., 2019.

[153] United Nations, Inter-agency Task Force on Financing for Development, 2019.

[154] Ibid.

[155] Ibid.

[156] Ibid.

[157] Dafe and Volz, 2015.

[158] UNEP, 2016a.

[159] Zadek and Robins, 2015.

[160] United Nations, Inter-agency Task Force on Financing for Development, 2019.

[161] Schoenmaker, 2018.

[162] Mercer, 2018.

[163] European Commission, 2019.

[164] Reuters, 2019b.

[165] Stuart and Woodroffe, 2016.

[166] Noori, 2017.

[167] Lee and.Trimi, 2018.

[168] UNEP, 2018.

[169] Duflo, 2012.

[170] Beaman et al., 2012.

[171] Krause et al., 2018.

[172] UNDP, 2013.

[173] United Nations Entity for Gender Equality and the Empowerment of Women (UN-Women), 2019.

[174] van Holm et al., 2017.

[175] UNEP, 2019b.

[176] Leach et al., 2012.

[177] Ely et al., 2013.

[178] Pansera, 2013.

[179] Schellnhuber, et al., 2011.

[180] Hertwig, and Grüne-Yanoff, 2017.

[181] United Nations Children's Fund (UNICEF), 2014.

[182] German National Academy of Science Leopoldina, 2018.

[183] UNEP, 2019b.

[184] United Nations Research Institute for Social Development (UNRISD), 2017.

[185] Abrahamse and Steg, 2013; Steg et al., 2015.

[186] Wakefield et al., 2010.

[187] Evans, 2002.

[188] Steg, 2014.

[189] Johnson and Goldstein, 2003.

[190] Frederiks et al., 2015.

[191] Mwangi, 2018.

[192] Colfer, 2010.

[193] Evans et al., 2014.

[194] Ojha et al., 2013.

[195] Colfer, 2010.

[196] Mwangi, 2018.

[197] Evans et al., 2014.

[198] Nilsson et al., 2017.

[199] Shim et al., 2017.

[200] Chaverra-Rodriguez et al., 2018.

[20] Organization for Economic Cooperation and Development (OECD), 2015b.

[202] UNESCO Institute for Statistics, 2019a.

[203] National Research Council USA, 2012; Gonzalez-Brambila et al., 2016

[204] Heeks et al., 2013.

[205] It is important to note that the development of inclusive innovation is not necessarily restricted to higher technical specifications. Inclusive innovation can be developed from cutting-edge research or it can consider fairly rudimentary or previously existing technologies. This, however, does not limit its potential to produce significant impact. UNCTAD, Innovation policy tools for inclusive development, (Note by the UNCTAD Secretariat, TD/B/C.II/25).

[206] UNCTAD, 2008, 2009, 2010, 2013c, 2014.

[207] UNCTAD, 2013a.

[208] Moreddu, C., 2016.

[209] GSM Association, 2019.

[210] International Telecommunication Union (ITU), 2018a.

[21] UNCTAD, 2013a.

[212] Lebel and Lorek, 2008.

[213] UN Secretary-General's Task Force on Digital Financing of the Sustainable Development Goals (DFTF), 2019.

[214] Oishi, et al., 2010.

[215] Balcazar et al., 2010.

216 Association for the Advancement of Assistive Technology in Europe and WHO, 2015.

217 Mutanga, 2016.

218 Helbing, 2016.

219 Sharma, 2016.

220 OECD, 2011.

221 OECD, 2012.

222 OECD, 2015a.

223 United Nations System Task Team of the Post-2015 United Nations Development Agenda, 2015.

224 UNDESA, 2018e.

225 German Advisory Council on Global Change (WBGU), 2019.

226 Bruns and Alba, 2016.

227 The suggestions are based on ongoing empirical research carried out within the WaterPower research project (www.waterpower.science) and the Governance and Sustainability Lab, Trier University.

228 WBGU, 2019.

229 United Nations, Secretary-General's High-level Panel on Digital Cooperation, 2019.

230 Stiglitz et al, 2017; Sen, 1999.

231 Bengtsson et al., 2018; Nunes et al., 2016.

232 Alvaredo et al. (eds), 2018.

233 Alkire et al., 2015; Alvaredo, et al. (eds), 2018.

234 World Bank, 2018b; World Bank 2018d

235 Alkire et al., 2018.

236 Burchi et al., 2019.

237 Alkire et al., 2018.

238 Ibid.

239 World Bank, 2018b.

240 Prüss-Ustün et al., 2014.

241 WHO, 2019a.

242 Water.org.

243 WHO, 2019a.

244 Ibid.

245 WHO, 2019c.

246 WHO and UNICEF, 2019.

247 United Nations Educational Scientific and Cultural Organization (UNESCO), 2019b.

248 WHO, 2019d.

249 Ibid.

250 WHO, 2010.

251 Drèze and Sen, 2013.

252 Bengtsson et al., 2018; Nunes et al., 2016.

253 Bengtsson et al., 2018.

254 Blanden, 2013.

255 International Commission on Financing Global Education Opportunity, 2016.

256 UNESCO, 2017b.

257 WHO, 2002.

258 Tanzania, Ministry of Health, 2016.

259 Nigeria, National Population Commission, 2014.

260 Alderman and Headey, 2017; Pamuk et al., 2011.

261 Adams et al., 2016; Munamati et al., 2016; Tiwari and Nayak, 2013.

262 Infectious diseases are diseases that pass from person to person and are caused by bacteria, viruses, parasites or fungi.

263 Fonkwo, 2008.

264 Mutter, 2015.

265 ILO, 2017a.

266 United Nations Office for Disaster Risk Reduction, 2015; United Nations Conference on Housing and Sustainable Urban Development, 2016; Fakhruddin, Bapon, Virginia Murray, and Fernando Gouvea-Reis, 2019.

267 United Nations, 2016b.

268 Linnerooth-Bayer and Mechler, 2015; Satterthwaite, 2007.

269 Helgeson et al., 2012.

270 Carter et al., 2007.

271 Talukder et al., 2016.

272 CARE International and Maplecroft, 2009.

273 Women Deliver 2017.

274 United Nations, 2007.

275 Stuart and Woodroffe, 2016.

276 United Nations, 2015.

277 Samman et al., 2018.

278 Ibid.

279 World Bank, 2018d.

280 UNCTAD, 2019a.

281 UNESCO, 2017b.

282 WHO, 2019e.

283 Thornicroft et al., 2017.

284 Heaton et al., 2016.

285 Souteyrand et al., 2008; Nabyonga et al., 2011.

286 WHO, 2019b.

287 WHO, 2017.

288 International Council of Nurses, et al., 2008.

[289] Willis-Shattuck et al., 2008; Mbemba et al.; 2013; Buykx et al., 2010.

[290] Adapted from a contribution by Negre, Mario, German Development Institute. Source: Lakner et al., 2019

[291] Lakner et al., 2019.

[292] Stewart, 2005; Mandel and Semyonov, 2005; Stewart et al. 2008.

[293] ILO, 2018a.

[294] Dahl, 2015; Bilecen and Barglowski, 2015.

[295] Ortiz et al, 2015.

[296] Schulte et al., 2015.

[297] Unver and Erdogan, 2015.

[298] P4G Partnerships, 2018.

[299] Reyers et al., 2017.

[300] Sagasti and Bezanson, 2001.

[301] United Nations Global Compact, and KPMG, 2016.

[302] ViiV Healthcare, 2019.

[303] Hove and Dubus, 2019.

[304] Mobarak et al., 2012.

[305] Amin et al., 2012.

[306] Ibid.

[307] Cameron et al, 2013.

[308] Bill and Melinda Gates Foundation, 2015.

[309] Evans, 2002.

[310] Kumar, 2011.

[311] International Association for the Study of Insurance Economics, 2005.

[312] UNCTAD, 2017a.

[313] Gehrke et al., 2015; Clasen et al., 2006.

[314] UNCTAD, 2018.

[315] Wilson et al., 2006.

[316] WHO, 2016.

[317] Hoek., 2018.

[318] United Nations Global Pulse, 2018; International Chamber of Commerce, 2018.

[319] International Chamber of Commerce, 2018.

[320] ITU, 2018c.

[321] GSM Association, 2018.

[322] ITU, 2018b.

[323] Alkire, 2013.

[324] UNESCO Institute for Statistics, 2018.

[325] UNESCO, 2017a.

[326] Ibid.

[327] McGinn et al., 2019.

[328] Ibid.

[329] Council on Foreign Relations, 2017.

[330] Licona, 2016.

[331] Ornelas, 2016.

[332] Duncan et al., 2010.

[333] Today, half of all people suffering from overlapping deprivations in health, education and assets are below the age of 18, according to the global MPI; and in 35 countries, half of all children are poor. Further, some studies estimate that inequality rates are even greater among children today than among adults.

[334] Marmot and Bell, 2016.

[335] Vaivada et al., 2017.

[336] Kimmel, 2006.

[337] Rashmi et al., 2015.

[338] Gertler et al., 2014.

[339] Ibid.

[340] World Bank Group, 2018a.

[341] Rao et al., 2014.

[342] Kuecken et al. 2014.

[343] Lutz, W et al. (eds.), 2014; Muttarak and Lutz., 2014.

[344] Muttarak and Lutz, 2014.

[345] Pachauri, 2004; Pachauri, 2012; Pachauri and Jiang, 2008; Farsi et al., 2007.

[346] Dobbs et al., 2012.

[347] Trilling and Fadel, 2009.

[348] Collado-Ruano, 2018.

[349] National Academies of Sciences, Engineering, and Medicine, 2017.

[350] Alhassan et al., 2016.

[351] Adua, E., et al., 2017.

[352] Bonfrer et al., 2016.

[353] Blanchet et al., 2012.

[354] Dake., 2018.

[355] Barroy et al., 2016.

[356] Dennis-Antwi et al., 2015.

[357] Gyedu et al., 2019.

[358] OECD, 2018c.

[359] The Human Development Index (HDI) is the best established alternative to GDP, being reported annually for all countries since 1989. However, its use for economic decision making remains limited and far from universal.

[360] Costanza et al., 2009.

[361] Van den Bergh, 2009.

362 Critiques and alternatives are available in Fleurbaey and Balnchet, 2013; Stiglitz et al. 2010.

363 Budlender, 2010.

364 Heffetz and Ligett, 2014; Fleurbaey and Balnchet, 2013.

365 Stiglitz et al., 2010.

366 Ibid.

367 Helbling, 2012.

368 Per capita statistic is the (unweighted) average across the five countries with the highest per capita consumption: International Energy Association Atlas, 2016.

369 UNEP, 2019a.

370 Ibid.

371 Sheth et al., 2011.

372 Zhan et al., 2014.

373 ECOSOC, 2019.

374 World Bank, 2018g.

375 UNEP, 2016a.

376 Sterner et al., 2019.

377 Deva, 2005.

378 Babic et al., 2017.

379 Country revenues are national government figures compared on exchange rate basis.

380 Alvaredo et al., (eds), 2018.

381 Ibid.

382 Dabla-Norris et al., 2015.

383 ILO, 2018b.

384 Bonnet et al., 2019.

385 ECOSOC, 2019.

386 Stiglitz, 2016; Neves et al., 2016; Gründler and Scheuermeyer, 2018.

387 Stiglitz, 2019.

388 Sterner et al., 2019.

389 Green et al., 2014.

390 High-Level Commission on Carbon Prices, 2017.

391 Ravi, 2001.

392 Coady et al., 2019.

393 Ibid.

394 Jewell et al., 2018.

395 Bousselmame, 2017.

396 Helbling, 2012.

397 Tvinnereim and Mehling, 2018.

398 The Economist, 2018.

399 Parry et al., 2018.

400 Coady et al., 2017; Pindyck, 2016; National Academies of Sciences, Engineering, and Medicine, 2017; Howard and Sylvan, 2015.

401 OECD, 2018d

402 Carl and Fedor, 2016.

403 The scheme envisages that the tax increase each year until emissions reduction goals are met; all revenue be returned to 'citizens through equal lump-sum rebates,' that there be a 'border carbon adjustment' to ensure that production does not shift abroad to less stringent locations, and be revenue neutral to 'avoid debates over the size of government.' (Wall Street Journal, 2019).

404 Eneh, 2017.

405 Del Río and Burguillo, 2008; Johnstone and Kivimaa, 2018.

406 Arntz et al., 2016.

407 Food and Agriculture Organization of the United Nations (FAO), 2012.

408 Task Force on Just transition for Canadian Coal Power Workers and Communities, 2018.

409 Ostry et al., 2019.

410 Inter-agency Task Force on Financing for Development,2019.

411 Ibid. Section 2.1.

412 Ibid.

413 Fuest et al., 2013.

414 Kar and Spanjers, 2011.

415 Cash et al., 2003.

416 Acemoglu, 2012.

417 However, they are also applicable elsewhere, for example in rapidly urbanizing areas in developing economies. (Redclift, 2013).

418 Across OECD countries, for example, trade union membership has, on average, halved since 1985. Organization for Economic Cooperation and Development (OECD, 2019a).

419 Global Commission on the Future of Work, 2019.

420 Non-standard work has been present in other sectors such as cultural and creative industries, and in the temporary work agencies. Collective bargaining arrangements in these sectors showed the ability of systems to adapt and change. (OECD, 2019a).

421 Blackett, A., 2012.

422 UNCTAD, 2018.

423 UNCTAD, 2019c.

424 Grubler et al., 2018.

[425] World Economic Forum, 2018.

[426] Li et al., 2016.

[427] Krueger et al., 2018.

[428] New Climate Economy, 2018.

[429] Some African countries including Rwanda, South Africa, and Nigeria launched the African Circular Economy Alliance in late 2017 in order to develop, together with the World Economic Forum and the Global Environment Facility, a continent-wide alliance that will spur Africa's transformation to a circular economy. (Rogge and Reichardt, 2016; Genovese et al., 2017).

[430] Berg et al., 2018 ; Ellen MacArthur Foundation 2013 ; Murray et al., 2017.

[431] Harvard Business Review, 2017; Reuters, 2017; Caldecott, 2017; Institute for Advanced Sustainability Studies (IASS), 2017.

[432] Jakob and Steckel, 2016; Nguyen et al., 2017.

[433] Barrientos, 2008.

[434] Pinho et al., 2014.

[435] Reiche et al., 2000.

[436] Carbon Tracker Initiative and Grantham Research Institute, 2013.

[437] IPCC, 2015.

[438] McGlade and Ekins, 2015.

[439] Ansar et al., 2013.

[440] International Renewable Energy Agency (IRENA), 2017.

[441] The Economist, 2016.

[442] Bretschger and Soretz, 2018.

[443] Caldecott and Robins, 2014.

[444] The food system encompasses agricultural production, the processing and distribution of food, and food consumption (which can be contextualized in the form of demand, diets, and trade).

[445] Ericksen, 2008.

[446] Campbell et al., 2017.

[447] FAO, 2019c.

[448] Hunter et al., 2017.

[449] FAO, 2018a.

[450] Ibid.

[451] Springmann et al., 2018.

[452] Nicolopoulou-Stamati et al., 2016.

[453] Willett et al., 2019; Searchinger et al., 2019.

[454] Springmann et al., 2018.

[455] Carvajal-Yepes et al., 2019.

[456] Asseng et al., 2018.

[457] Campbell and Thornton, 2014.

[458] Ibid.

[459] Alwang and Norton, 2014.

[460] Birthal et al., 2005.

[461] International Panel of Experts on Sustainable Food Systems (IPES-Food), 2017b.

[462] Ibid.

[463] Ibid.

[464] Beddington et al., 2012.

[465] Ibid.; World Commission on Environment and Development, 1987.

[466] Beddington et al., 2012.

[467] Syakila and Kroeze, 2011.

[468] Vermeulen et al., 2012.

[469] Springmann et al., 2018.

[470] Beddington et al., 2012.

[471] FAO. 2013.

[472] Ibid.

[473] Schmidt-Traub et al., 2019.

[474] Adapted from Carvajal-Yepes et al., 2019.

[475] For example, European Plant Protection Organization (EPPO), the U.S. NPDN, the European Union Reference Laboratories, and the Global influenza surveillance and response system (GISRS) coordinated by WHO.

[476] United Nations, Human Rights Council, 2010.

[477] Zhang et al., 2018.

[478] Berg et al., 2009.

[479] The Economics of Ecosystems and Biodiversity (TEEB), 2018; International Panel of Experts on Sustainable Food Systems (IPES-Food), 2017a.

[480] Nelson et al., 2010.

[481] Asian Development Bank, 2013.

[482] UNCTAD, 2011.

[483] UNCTAD, 2017b.

[484] Van Asseldonk et al., 2015.

[485] Russell, 2018

[486] For review, see Greatrex et al., 2015.

[487] Hochrainer-Stigler et al, 2014

[488] De Schutter 2015.

[489] International Panel of Experts on Sustainable Food Systems (IPES-Food), (2017b).

[490] Beddington et al., 2012.

[491] Poore and Nemecek, 2018.

[492] Campbell, 2014

[493] Eyhorn et al., 2019.

[494] Schrama et al., 2018; Badgley et al., 2007; Seufert et al., 2012.

[495] Altieri, 2018.

[496] "4 per 1000" initiative.

[497] Fischer et al., 2015.

[498] Ibid.

[499] Idrisa et al., 2012.

[500] See Space climate observatory website: www.spaceclimateobservatory.org/?lang=en.

[501] UNCTAD, 2017b.

[502] Ibid.

[503] Springmann et al., 2018; World Resources Institute, 2018.

[504] World Resources Institute, 2018.

[505] Rosegrant et al., 2013.

[506] Nijdam et al., 2012.

[507] Parfitt et al., 2010

[508] Stoll-Kleemann, and Schmidt, 2017; Willett et al., 2019.

[509] International Food Policy Research Institute, 2018.

[510] Kaljonen et al., 2019.

[511] UNDESA, 2018a.

[512] Rocha and Lessa, 2009; International Panel of Experts on Sustainable Food Systems (IPES-Food), 2019.

[513] FAO, 2017a.

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[516] Interagency Coordination Group on Antimicrobial Resistance, 2019.

[517] Lu and Tian, 2017.

[518] Godfray et al., 2010.

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[521] Aloe et al., 2014.

[522] FAO, 1996.

[523] Butterbach-Bahl et al., 2013.

[524] Lassaletta et al., 2014.

[525] Agardy et al., 2005.

[526] Garcia and Rosenberg, 2010.

[527] Naylor and Burke, 2005.

[528] FAO, 2019a.

[529] World Bank, 2018c.

[530] Mattick et al., 2015.

[531] Benke and Tomkins, 2017.

[532] Rico-Campà et al., 2019.

[533] Conlon and Bird., 2015; Bodirsky et al., 2014; FAO, 2019d; Foley et al., 2011; Godfray et al., 2010; Lassaletta et al., 2014; Lu and Tian, 2017.

[534] Momblanch et al., 2019.

[535] Baccouri, 2018; Mrabet et al., 2012.

[536] FAO, 2015.

[537] International Bank for Reconstruction and Development and World Bank, 2012.

[538] Kassam et al., 2012.

[539] AbuZeid, Elradawi and CEDARE, 2012.

[540] Ministère de l'Agriculture, des Ressources Hydrauliques et de la Pêche de Tunisie and Agence de la Vulgarisation et de la Formation Agricoles en Tunisie, 2016; Réseau associatif de développement durable des oasis (RADDO); International Center for Biosaline Agriculture, 2019; ReliefWeb, 2019; Baccouri, 2008; Chibani et al., 2018; FAO and the German Agency for International Cooperation, 2015; Mrabet et al., 2012; International Bank for Reconstruction and Development and World Bank, 2012; Système Aquifère du Sahara Septentrional (SASS), 2013a; Système Aquifère du Sahara Septentrional (SASS), 2013b; Al-Zubari, 2016.

[541] International Renewable Energy Agency (IRENA), 2019a.

[542] Ibid.; World Bank, 2019a; United Nations, 2019d.

[543] United States Environmental Protection Agency, 2017.

[544] UNEP, 2018.

[545] UNEP, 2019b.

[546] International Energy Agency (IEA), 2019.

[547] IRENA, 2019a; United Nations, 2019d.

[548] International Institute for Applied Systems Analysis (IIASA), 2018.

[549] Davis and Socolow, 2014; Oil Change International, 2016.

[550] IPCC, 2018; Weindl et al, 2017

[551] Peters et al., 2017

[552] International Renewable Energy Agency (IRENA), (2019b).

[553] Ibid.

[554] Dunlap and McCright, 2011.

[555] Oreskes and Conway, 2010; Brulle, 2014.

[556] UNEP, 2019b.

[557] UNEP, 2019b.

[558] Environmental and Energy Study Institute (EESI), 2019a; Masaud et al., 2010; Barton and Infield, 2004.

[559] National Academies of Sciences, Engineering, and Medicine, 2018.

[560] Fuss et al., 2016.

[561] IPCC, 2014; Intergovernmental Panel on Climate Change, 2018; Pachauri et al., 2014; The Royal Society and the Royal Academy of Engineering, 2018.

[562] IPCC, 2018.

[563] Environmental and Energy Study Institute (EESI), 2015.

[564] United States Environmental Protection Agency (US EPA), 2017.

[565] McKinsey & Company, 2019.

[566] IEA, 2018b.

[567] European Commission, 2017.

[568] UNEP, 2019b.

[569] Cox et al., 2018.

[570] Hoekstra, 2019.

[571] Coady et al., 2017; International Energy Agency (IEA), 2019.

[572] Coady et al., 2017.

[573] Ibid.

[574] Ricke et al., 2018; Machol and Rizk, 2013.

[575] Coady et al., 2017; Pindyck, 2016; National Academies of Sciences, Engineering, and Medicine, 2017; Howard and Sylvan, 2015.

[576] Bonney et al., 2018; Coady et al., 2017; OECD, 2018a; OECD, 2018d.

[577] IEA, 2018a.

[578] Coady et al., 2017.

[579] Karvonen et al., 2017.

[580] Searchinger et al, 2018.

[581] IPCC, 2018.

[582] International Institute for Applied Systems Analysis, 2018.

[583] REN21, 2018.

[584] Mead, 2018.

[585] Caldecott et al., 2016; Climate Analytics, 2016.

[586] International Carbon Action Partnership, 2018; Freire-González, 2019; and Puig-Ventosa, 2019.

[587] Stiglitz et al., 2017.

[588] UNDESA, 2019c.

[589] REN21, 2019.

[590] Devine-Wright, 2012; Upham et al., 2019.

[591] Energy Institute, 2018.

[592] UNCTAD, 2019c.

[593] Network for Greening the Financial System, 2019.

[594] Reuters, 2019a; Togo, 2018; United States Agency for International Development, 2018

[595] Greece, 2018; Forouli et al., 2019

[596] World Nuclear Association, 2019.

[597] Warner and Heath, 2012.

[598] UNDESA, 2019c.

[599] Clean Cooking Alliance, 2018; International Institute for Sustainable Development, 2011; International Institute for Sustainable Development and Global Subsidy Initiative, 2018; Puzzolo et al., 2014; Renner et al, 2017; Thoday et al., 2018; Yayasan Dian Desa, 2016; World Bank, 2017a; Staton and Harding, 2002; Kojima, 2011.

[600] Meletiou et al, 2019.

[601] There is no universal definition of "city." The United Nations defines cities loosely as "places where large numbers of people live and work" that are "hubs of government, commerce and transportation." Some countries like Denmark and Iceland classify any settlement of 200 or more people as "urban," while others set the numerical bar at 20,000 (Netherlands), 30,000 (Mali) or 50,000 (Japan). Other countries include additional factors in their definition: Bhutan, for instance, requires a certain population density and evidence of future economic growth potential.

[602] United Nations, (2018a).

[603] UNDESA, 2013; According to UN-Habitat, a slum household lacks at least one of the following: (1) Durable housing of permanent nature that protects against extreme climate conditions; (2) Adequate living space, which means no more than three people sharing the same room; (3) Easy access to safe water in sufficient amounts at an affordable price; (4) Access to sufficient level of sanitation in the form of a private or public toilet shared by a reasonable number of people; and (5) Security of tenure that prevents forced evictions.

[604] Delgado et al., 2015.

[605] UN Habitat, 2016

[606] Merkens et al., 2016.

[607] Disability Inclusive and Accessible Urban Development Network, 2016.

[608] Webster and Sassen, 2009

[609] Slavova and Okwechime, 2016; African Development Bank Group, 2012.

[610] United Nations, 2017; Teferi and Newman, 2018.

[611] Tusting et al., 2019.

612 Intergovernmental Panel on Climate Change, 2014.

613 Disability Inclusive and Accessible Urban Development Network, 2016.

614 ECOSOC, 2019.

615 World Bank, 2019c.

616 United Nations, 2017; Angel et al., 2011; UNDESA, 2018c; UN Habitat, 2016.

617 Patrick, 2012.

618 Patrick, 2012.

619 International Resource Panel,UNEP, 2018.

620 Cheshmehzangia and Butters, 2016

621 Rahman, 2002.

622 United Nations Conference on Housing and Sustainable Urban Development , 2015.

623 Wang et al., 2012

624 Heinonen and Junnila, 2011; Also, a study from the University of California-Berkeley found that in the United States, urban households contribute 50 per cent below the national average of CO_2 per capita, while the suburban contribution is nearly double the US average. (Jones and Kammen, 2014)

625 Mora et al., 2013; Mora et al., 2017.

626 Chapman et al., 2017.

627 Ibid.

628 Recognizing the need for this radical transition, the United Nations' global community met in 2016 in Quito, Ecuador, to agree on a "New Urban Agenda." The New Urban Agenda calls for an "urban paradigm shift," a proactive re-imagining of the city as a place that is human-centered and sustainable, and accessible to all regardless of gender, age, disability, ethnicity or culture is environmentally sustainable. The New Urban Agenda envisions cities as the embodiment of the values of the Agenda 2030, places where no one is left behind. (UN-Habitat, 2014; UN-Habitat 2017)

629 Ayres 2018

630 Russell, 2013 ; Newman et al, 2016

631 World Bank, (2017b).

632 United Nations Environment Programme (UNEP), 2013.

633 African Development Bank, 2018.

634 Global Sustainable Development Report, 2018.

635 United Nations Secretary-General's High-Level Advisory Group on Sustainable Transport, 2014.

636 Mohit, 2012; Muggah, 2018

637 Csomós and Géza, 2016; Somers et al., 2016; Mulas et al., 2016.

638 Euromonitor International, 2016.

639 Inter-American Development Bank, 2018.

640 For information on assessments to date, see UNCTAD, 2019b.

641 Kitchin, 2014

642 World Bank, 2015a.

643 Acuto et al., 2018.

644 UN-Habitat, 2017.

645 Municipalities are adopting the concept of "liveable city" in their planning documents in developed and developing countries. See for instance eThekwini Municipality (including Durban) in South Africa, Integrated Development Plan Annual Review, 2016/2017.

646 Bigio and Dahiya, 2004,

647 The World in 2050, 2018; PwC, 2017

648 Lobo, 2016; Shah et al., 2015

649 UNDESA, 2018c.

650 UNDESA, 2018b.

651 Gashi and Watkins, 2015; PwC Global, 2016.

652 Brookings Institution, 2018; World Bank, 2015b; Marais et al., 2016

653 International Resource Panel, UNEP, 2017.

654 World Bank, 2010; United Nations High-Level Political Forum on Sustainable Development, 2018; Moran et al., 2018;

655 IPCC, 2014.

656 UNDESA, 2016a; Disability Inclusive and Accessible Urban Development Network, 2016; Disability-inclusive DRR Network for Asia and the Pacific, 2013.

657 The Brookings Institution, 2017; Earley, 2018; ITU, 2018d) Ramasamy et al., 2017; Nsengimana, 2017

658 Verchick and Govind, 2015.

659 Cladera et al., 2009.

660 Steuteville, 2017; Liu and Liu, 2018.

661 Olubunmi et al., 2016 ; Frantzeskaki et al., 2003;

662 Mäenpää and Faehnle, 2017.

663 Helby Petersen, 2019; Ketterer and Powell, 2018

664 World Business Council for Sustainable Development, 2016.

665 ibid

666 Boden, 2017; Finland, Finnish Ministry of the Environment, 2019; Scrivener et al., 2017; Scrivener et al., 2018.

667 Buck, 2017.

668 UN-Habitat, 2016.

669 Cities Alliance, 2014; C40 Cities Climate Leadership Group and ARUP, 2015; Lopes et al., 2018; United Nations Global Compact, 2017; C40 Cities, 2014

670 UN-Habitat, 2016.

671 International Resource Panel, UNEP, 2018.

672 Elmqvist et al., editors, 2018.

673 Chiabaia, 2018

674 United Nations Conference on Housing and Sustainable Urban Development, 2015.

675 Camps-Calveta et al., 2016.

676 Kabisch et al., 2017; Keniger et al., 2013

677 Flandroy et al., 2018.

678 Ibid.; Kabisch et al., 2017; Keniger et al., 2013.

679 Böbel et al., 2018; Carabotti, 2015.

680 Oberlack and Eisenack, 2014.

681 Landy (ed), 2018; McFarlane, 2012

682 Dehghani-sanij et al., 2015.

683 Adapted from a contribution by Albert S. Fakhoury, President, Council for International Accreditation of Architecture & Design (CIAAD)

684 United Arab Emirates' Government portal, 2019.

685 Elmqvist et al. (eds), 2018.

686 Ambole 2018.

687 Elmqvist et al. eds), 2018.

688 International Resource Panel, UNEP, 2018.

689 Patti and Polyák (eds), 2017.

690 Mahendra and Beard, 2018; Elmqvist, et al., 2018.

691 Butterfield et al., 2017.

692 Garcia-Neto et al., 2018.

693 UNESCO, 2019b; Van der Helm et al. 2017; Hashem, 2017

694 See for instance the Urban Agenda of the EU, European Commission. European Commission, 2017.

695 Lusk and Gunkel, 2018.

696 Sisson, 2018.

697 Fünfgeld, 2015; Bulkeley et al., 2014.

698 Bansard et al., 2017.

699 Paris, London, Los Angeles, Quito, Cape Town, Seattle, Auckland, Mexico City, Milan, Rome, Vancouver, Copenhagen and Barcelona.

700 Wentworth, 2018.

701 Bulkeley and Castán Broto, 2013; Gordon and Johnson, 2018.

702 International Council for Local Environmental Initiatives, 2019.

703 European Commission, European Green Capital Award, 2019

704 Rockström et al., 2009.

705 IBPES, 2019.

706 Rockström et al., 2009.

707 Steffen, et al., 2015.

708 Box adapted from contribution by Susanne Wymann von Dach, CDE, University of Bern. Source: Wymann von Dach et al., 2018.

709 Kulonen et al., 2019.

710 Schober, 2009

711 FAO, 2019e.

712 Herrero et al., 2013

713 Nolte et al., 2016.

714 Ibid.

715 Arora, 2019

716 Gore, 2015.

717 Kreft et al., 2014.

718 Orenstein and Reyes, 2017

719 Bowman and Minas, 2019.

720 Blasiak et al., 2018.

721 Eekhout and de Vente, 2019.

722 Wood et al., 2018.

723 Policymakers would find key ecosystem service allies in insects and pollinators for supporting food systems, biodiversity, pollination, seed dispersal, water filtration, carbon sequestration, and organic matter cycling, contributing worth $57 billion per year globally. (Dangles and Casas, 2019; Losey and Vaughan, 2006)

724 Spierenburg at al., 2008.

725 IPCC, 2014

726 Edenhofer et al., 2013.

727 Schultz et al., 2015; Österblom and Folke, 2013.

728 Jordan et al., 2018; Dorsch and Flachsland, 2017

729 Ostrom, 2010; Cole, 2015; Carlisle and Gruby, 2017.

730 Duit and Galaz, 2008; Heikkila et al., 2018; Tormos-Aponte et al, 2018; Piketty and Goldhammer, 2014.

731 Gupta et al., 2013; Biermann et al., 2012; Biggs et al., 2012; Cole, 2015

732 Jordan et al., 2018.

733 Adapted from a contribution by Dirk Bunke, Öko-Institut; Nils Simon, Adelphi; Johanna Rose, German Environment Agency; and Christopher Blum, German Environment Agency

[734] Galaz et al., 2012; Jordan et al., 2018.

[735] Folke et al., 2005; Pahl-Wostl, 2009.

[736] Plummer and Armitage, 2007; Cox et al., 2010.

[737] Poteete et al., 2010.

[738] Abbott, 2017.

[739] Galaz et al., 2012; Cole, 2015; Galaz et al., 2016 ; Duit and Galaz, 2010

[740] Rueff et al., 2015.

[741] Global Chemical Leasing Programme of UNIDO.

[742] OECD, 2018e.

[743] Global Chemical Leasing Programme of UNIDO.

[744] Byerly et al., 2018.

[745] Evans et al., 2017.

[746] Steffen et al., 2018.

[747] Ostrom et al., 1994.

[748] Davis et al., 2018; IPCC, 2018.

[749] Fairhead et al., 2012; Scoones at al., 2015; Cao et al., 2010.

[750] Inam-ur-Rahim et al., 2011.

[751] Luyssaert et al., 2008.

[752] Abernethy et al., 2016 ; Damette and Delacote, 2011.

[753] Davis et al., 2018.

[754] Box adapted from contribution by David Smith, University of the West Indies and Pradeepa Bholanath, Guyana Forestry Commission

[755] Mora et al. (eds), 2012; Pearson et al., 2014; Romijn et al., 2015; Bholanath and Cort, 2015; Pickering et al., 2019

[756] Ostrom, Elinor, 2010.

[757] Box adapted from a contribution by Hannah Janetschek, German Development Institute; Clara Brandi, German Development Institute; and Adis Dzebo, Swedish Environment Institute. Source: Brandi et al. 2017 ; Dzebo et al. ; 2018; Breuer et al. 2019 ; Janetschek, et al. 2019

[758] Young, 2011; Young, 2013; UNEP, 2019b.

[759] Miles et al., 2001.

[760] Parson, 2003; Epstein et al., 2014.

[761] Jordan et al., 2018.

[762] International Panel of Experts on Sustainable Food systems (IPES-Food), 2016.

[763] Healy and Barry, 2017

[764] Martinez-Alier et al., 2014.

[765] Crona et al., 2015; Bennett, 2018.

[766] Gruby et al., 2016.

[767] Bennett et al., 2015.

[768] UNEP, 2019b; Di Franco et al., 2016 ; Pomeroy et al., 2007

[769] Piketty and Goldhammer, 2014; Österblom et al., 2017; Kubiszewski et al., 2013

[770] Kubiszewski et al., 2013

[771] Royal Government of Bhutan, Ministry of Agriculture and Forests Department of Forests and Park Services Thimphu, 2017.

[772] Young, 2011; Jordan et al., 2015.

[773] Betsill et al., 2015; Hale, 2016; Ayling and Gunningham, 2017

[774] Box adapted from contribution by Jean Albergel, French Research Institute for Development (IRD)

[775] Bielsa and Cazcarro, 2015; Molle, 2008.

[776] Wester et al., editors, 2019.

[777] Amani and Paturel, 2017.

[778] Adapted from contribution by Eeva Furman, Finnish Environment Institute (SYKE)

[779] Adapted from contribution by Sir Peter Gluckman, International Science Council and Centre for Science in Policy, Diplomacy and Society, Public Policy Institute and Liggins Institute, University of Auckland

[780] ECOSOC, 2019; United Nations, 2019c.

[781] United Nations and World Bank, 2018.

[782] UNESCO, 2019b.

[783] Ibid.

[784] Wada et al., 2011.

[785] UNEP, 2016.

[786] Ramankutty et al., 2018 ; Venter et al., 2016.

[787] IPBES, 2019.

[788] IPBES, 2018.

[789] Ellis, 2019.

[790] Land Rights Now, 2019.

[791] International Land Coalition, 2019

[792] Pendrill et al., 2019.

[793] Transparent Supply Chains for Sustainable Economies (TRASE).

[794] Rights and Resources Initiative, 2015.

[795] Bonn Challenge.

[796] Global Land Programme.

[797] Munroe et al., 2019.

Chapter III: Science for sustainable development notes (798-894)

798 Science Council, 2018.

799 Stirling, 2010; DeFries and Nagendra, 2017; Head, 2018.

800 Adapted from Messerli and Bieri, 2018; inspired by Stacey, 1996.

801 Cornell et al., 2013; Durose et al., 2018; Hickey et al., 2018 ; Willyard et al., 2018.

802 Jasanoff et al. (eds), 1995.

803 Fleck, 1980; Carson, 2002; Kuhn, 2012; Fleck et al., 2017; Kuhn and Hacking, 2012

804 Crutzen, 2002; Steffen et al., 2015; Kates et al., 2001; Mooney, 2016.

805 Erb et al., 2016

806 Ellis, 2018.

807 Van Noorden, 2015; International Science Council.

808 Steffen, et al., 2017; The World in 2050, 2018.

809 Millennium Ecosystem Assessment, 2005; Steffen et al, 2006; International Social Science Council and UNESCO, 2016.

810 UNESCO, 2017c.

811 International Council for Science, 2017; Nilsson, 2017.

812 Rennkamp and Boulle, 2018.

813 Adapted from a contribution from International Science Council, World Federation of Engineering Organizations, and InterAcademy Partnership.

814 UNDESA, 2014.

815 There were 7.8 million full-time equivalent researchers in 2013, representing growth of 21 per cent since 2007. (UNESCO, 2015).

816 Haas, 2016; UNEP, 2017a.

817 UNDESA, 2014.

818 Verburg et al., 2015; Anderson and Peters, 2016; Creutzig, 2016; UNEP, 2017a

819 All external contributions collected through the open call for inputs are available on the GSDR2019 website

820 Nakamitsu, 2018.

821 Rueff and Rahim, 2016.

822 Kothari et al., 2014; Chassagne, 2018.

823 See also: UNESCO, 2019a.

824 World Animal Protection, 2015.

825 FAO, 2018b.

826 United Nations Global Compact, 2017.

827 Schneider et al., 2019.

828 Chasek et al., 2016; Gellers, 2016.

829 Lim et al., 2018.

830 Biermann et al., 2017.

831 The World in 2050, 2018.

832 Box adapted from contribution by Nebojsa Nakicenovic, International Institute for Applied Systems Analysis and The World in 2050. Source: The World in 2050, 2018.

833 Mazzucato, 2018.

834 Wren-Lewis, 2019.

835 UNESCO Institute for Statistics, 2019c; Map produced by Centre for Development and Environment (CDE), University of Bern.

836 UNCTAD, 2011.

837 International Network of Women Engineers and Scientists (INWES)

838 Norgaard, 2015.

839 Naustdalslid, 2011.

840 Kates et al., 2001.

841 Cash et al., 2003.

842 Kates, 2011.

843 Gergen, 2015; Hickey et al., 2018.

844 Kates, 2018.

845 Van den Hove, 2007; German Advisory Council on Global Change, 2011; Sarewitz, 2015.

846 Strohschneider and Brodocz, et al. (eds), 2014.

847 New Partnership for Africa's Development, 2019.

848 Cai, 2018.

849 Scoones et al., 2018.

850 Woelert and Millar, 2013; Bromham et al., 2016.

851 Rhoten and Parker, 2004; Kueffer et al., 2012.

852 Kueffer et al., 2012.

853 Wiesmann et al., 2011.

854 Zondervan, 2017.

855 Acuto et al., 2018.

856 World Overview of Conservation Approaches and Technologies (WOCAT), 2019

857 Transformative Cities, 2019.

858 United Nations Secretary-General's Independent Expert Advisory Group on a Data Revolution for Sustainable Development, 2014

859 Brainard, 2019.

860 Box adapted from contribution by SYKE, Finland.

861 Arza and Fressoli, 2017.

862 Fecher and Friesike, 2014.

863 McKiernan et al., 2016.

[864] Ibid.

[865] Brainard, 2019.

[866] Owen et al., 2013.

[867] Farley, 2014.

[868] Wiek et al., 2011; Wiek et al., 2015.

[869] Barth et al., 2015.

[870] Wiesmann et al., 2011.

[871] Lubchenco et al., 2015; Scoones et al., 2015; Fazey et al., 2018.

[872] Sarkki et al., 2015; Isgren, 2017.

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[874] Cornell et al., 2013; Berg and Lidskog, 2018.

[875] Spatial Informatics Group, 2016.

[876] OneMap Myanmar, 2019.

[877] International Centre for Integrated Mountain Development (ICIMOD), 2018.

[878] Nile Basin Initiative, 2019.

[879] Dauvergne and Lister, 2012; Österblom et al., 2017.

[880] Cash et al., 2003.

[881] Cornell et al., 2013.

[882] Zinsstag et al., 2011.

[883] Westley et al., 2011; Kaljonen et al., 2019.

[884] SDG Labs, Seedbeds of Transformation, 2018

[885] Steps Centre, 2018.

[886] Institute for Advanced Sustainability Studies, 2018; OECD, 2018b.

[887] UNESCO, 2015.

[888] Research Fairness Initiative.

[889] Lahsen et al., 2013.

[890] Committee on Data International Science Council, 2019.

[891] Adapted from contribution by the Center for Development and Environment (CDE), University of Bern, and Commission for Research Partnerships with Developing Countries (KFPE)

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Annex I

Annex I

Ministerial declaration of the 2016 high-level political forum on sustainable development, convened under the auspices of the Economic and Social Council, on the theme "Ensuring that no one is left behind"

[E/HLS/2016/1]

We, the Ministers and high representatives, having met at United Nations Headquarters in New York,

1. *Pledge* that no one will be left behind in implementing the 2030 Agenda for Sustainable Development. In this first high-level political forum for sustainable development to be convened following its historic adoption, we underscore the need for its 17 Sustainable Development Goals and 169 targets to be met for all nations and peoples and for all segments of society. We stress that the 2030 Agenda is people-centred, universal and transformative and that its Goals and targets are integrated and indivisible and balance the three dimensions of sustainable development — economic, social and environmental. It is a plan of action for people, planet and prosperity that also seeks to strengthen universal peace in larger freedom, to be implemented by all countries and stakeholders, acting in collaborative partnership. We reaffirm all the principles recognized in the Agenda, and that eradicating poverty in all its forms and dimensions, including extreme poverty, is the greatest global challenge and an indispensable requirement for sustainable development;

2. *Emphasize* that the high-level political forum is called to provide political leadership, guidance and recommendations for the implementation of sustainable development commitments, and that it has a central role in overseeing a network of follow-up and review processes of the 2030 Agenda at the global level, working coherently with the General Assembly, the Economic and Social Council and other relevant organs and forums, in line with existing mandates. It will, inter alia, facilitate the sharing of experiences and best practices and promote system-wide coherence and coordination of sustainable development policies, considering that the 2030 Agenda is applicable to all, taking into account different national realities, capacities and levels of development and respecting each country's policy space, and to be implemented consistent with the sovereign rights and obligations of States under international law and with the Charter of the United Nations;

3. *Welcome* early efforts in implementing the 2030 Agenda at all levels, building on the achievements of the Millennium Development Goals and seeking to address their

unfinished business. We are encouraged by these efforts and, in this first year of its implementation, look forward to further progress in, inter alia, revitalizing and enhancing the Global Partnership for Sustainable Development, aligning existing policies with the new global plan of action, increasing policy and system-wide coherence and integration for achieving the Sustainable Development Goals and targets, addressing existing and emerging challenges, enhancing national capacities for evidence-based and data-driven decision-making, and favouring participatory, cooperative and enabling environments at all levels. We take note with appreciation of the Secretary-General's first annual progress report on the Sustainable Development Goals;

4. *Have considered* the theme of the 2016 high-level political forum, "Ensuring that no one is left behind", and highlight in this regard that the dignity of the human person is fundamental, and that we endeavour to reach the furthest behind and the most vulnerable first. To ensure that no one is left behind, we are working to eradicate poverty and hunger and achieve sustainable development in its three dimensions, inter alia, by promoting inclusive economic growth, protecting the environment and promoting social inclusion in an integrated manner. We will ensure gender equality and women's and girls' empowerment. We will also promote peaceful and inclusive societies, respect and promote all human rights, and promote an equitable global economic system in which no country, people or person is left behind, enabling decent work and productive livelihoods for all, while preserving the planet for our children and future generations. We strive for a world of peace, free of fear and violence and free from terrorism. We pledge to make such a world a reality;

5. *Commit*, in our endeavour to ensure that no one is left behind, to focusing our efforts where the challenges are greatest, including by ensuring the inclusion and participation of those who are furthest behind. We deem it of critical importance, in this regard, to protect and empower people who are vulnerable. We recall that those whose needs are reflected in the 2030 Agenda include all children, adolescents, youth, persons with disabilities, people living with HIV/AIDS, older persons, indigenous peoples, refugees and internally displaced persons, migrants and peoples living in areas affected by complex humanitarian emergencies, and peoples in areas affected by terrorism and conflict;

6. *Emphasize* that, to ensure that no one is left behind, we are committed to making real a world free of poverty, hunger, disease, want and environmental degradation, where all life can thrive; a world with universal literacy and with equitable and universal access to quality education at all levels and to health care and social protection, where physical, mental and social well-being are assured, where we reaffirm our commitments regarding the human right to safe drinking water and sanitation and where there is improved hygiene, and where food is sufficient, safe, affordable and nutritious;

7. *Recognize* that sustainable development cannot be realized without peace and security, and that peace and security will be at risk without sustainable development. The 2030 Agenda recognizes the need to build peaceful, just and inclusive societies that provide equal access to justice and that are based on respect for human rights, including the right to development, on effective rule of law and good governance at all levels and on transparent, effective and accountable institutions. Factors which give rise to violence, insecurity and injustice, such as inequality, corruption, poor governance and illicit financial and arms flows, are addressed in the Agenda. We must redouble our efforts to resolve or prevent conflict and to support post-conflict countries, including by ensuring that women have a role in peacebuilding and State-building. We call for further effective measures and actions to be taken, in conformity with international law, to remove the obstacles to the full realization of the right of self-determination of peoples living under colonial and foreign occupation, which continue to adversely affect their economic and social development as well as their environment;

8. *Emphasize* that universal respect for human rights and human dignity, peace, justice, equality and non-discrimination is central to our commitment to leaving no one behind. Our commitment also includes respect for race, ethnicity and cultural diversity, and equal opportunity, permitting the full realization of human potential and contributing to shared prosperity. We are committed to a world that invests in its children and youth and in which every child grows up free from all forms of violence and exploitation. We envision a world in which every woman and girl enjoys full gender equality and all legal, social and economic barriers to their empowerment have been removed. We will strive for a world where young women and young men are key agents of change, supported by a culture of innovation, sustainability and inclusiveness, to enable a better future for themselves and their communities; a just, equitable, tolerant, open, creative and socially inclusive world in which the needs of the most vulnerable are met;

9. *Also emphasize* our commitment to making real a world in which every country enjoys sustained, inclusive and sustainable economic growth and decent work for all, in which consumption and production patterns and the use of all natural resources are sustainable; a world in which development is climate-sensitive and respects biodiversity, where we restore and conserve and sustainably use all ecosystems and strengthen our cooperation to prevent environmental degradation and promote resilience and disaster risk reduction; a world where human settlements and the application of technology are inclusive, safe, resilient and sustainable and where there is universal access to safe, affordable, reliable

and sustainable transport and energy systems; a world in which humanity lives in harmony with nature and in which wildlife and other living species are protected;

10. *Stress* that realizing gender equality and the empowerment of all women and girls will make a crucial contribution to progress across all the Goals and targets. Women and girls should enjoy equal access to quality education at all levels, health-care services, economic and natural resources and civil and political participation as well as equal opportunities with men and boys for employment, leadership and decision-making at all levels. We will work for a significant increase in investments to close the gender gap and strengthen support for institutions in relation to gender equality and the empowerment of all women and girls at the global, regional and national levels. We strive for a world where all forms of discrimination and violence against women and girls will be eliminated, including through the engagement of men and boys. The systematic mainstreaming of a gender perspective into the implementation of the 2030 Agenda is crucial;

11. *Welcome* the numerous contributions made by the United Nations and other relevant intergovernmental bodies and forums to the implementation of the 2030 Agenda, including the General Assembly and the Economic and Social Council, the United Nations development system and the United Nations specialized agencies. In the context of the high-level segment of the Economic and Social Council, we welcome its annual work, including that of its functional and regional commissions and segments, which has been guided by the theme "Implementing the post-2015 development agenda: moving from commitments to results". The Council is key in supporting our efforts to ensure that no one is left behind by, inter alia, addressing existing and emerging challenges, facilitating multi-stakeholder participation and promoting system-wide coherence and coordination. We highlight the important contributions made by its forums on youth, on partnerships and on development cooperation; its segments on operational activities, on integration and on humanitarian affairs; its special meetings on inequality, on the El Niño phenomenon and on the Zika virus; and its dialogue on the longer-term positioning of the United Nations development system in the context of the 2030 Agenda, called to inform the upcoming quadrennial comprehensive policy review, among other activities related to the implementation of the 2030 Agenda. We look forward to the contributions of the Council and other relevant intergovernmental forums and bodies in the coming years, including on the thematic reviews of the 2030 Agenda;

12. *Stress*, in regard to the thematic discussion of the Council's high-level segment on "Infrastructure for sustainable development for all", the attention given by the 2030 Agenda to building resilient infrastructure and its particular connection with the promotion of inclusive and sustainable industrialization and the fostering of innovation. We are committed to addressing infrastructure gaps by, inter alia, improving investments and further building capacities within a coherent policy framework, and consider this key for reducing inequalities within and among countries. We also stress that infrastructure should be safe, accessible and people-centred, and promote economic integration and connectivity, to ensure that no one is left behind;

13. *Recognize* that the scale and ambition of the 2030 Agenda require a revitalized and enhanced Global Partnership for Sustainable Development to ensure its implementation, working in a spirit of global solidarity, in particular with the poorest and with people who are vulnerable. We are fully committed to this, and to moving from all commitments to results, working with all stakeholders. The provision of means of implementation, particularly as outlined under Goal 17 and under each Sustainable Development Goal, supported by the concrete policies and actions outlined in the Addis Ababa Action Agenda of the Third International Conference on Financing for Development, which is an integral part of the 2030 Agenda, is critical for achieving our ambitious goals and ensuring that no one is left behind;

14. *Welcome* in this regard, inter alia, the holding of the inaugural forum on financing for development, take note of its intergovernmentally agreed conclusions and recommendations, and look forward to further advancement in the follow-up process. We also welcome the work of the United Nations Inter-Agency Task Force. We further welcome the progress made in operationalizing the three components of the Technology Facilitation Mechanism and the holding of the inaugural multistakeholder forum on science, technology and innovation for the Sustainable Development Goals, which is important, inter alia, to help facilitate the development, transfer and dissemination of relevant technologies for the Sustainable Development Goals. We look forward to the establishment of the online platform as part of the Mechanism. We also welcome the progress made in operationalizing the technology bank for the least developed countries;

15. *Highlight* the importance of participatory and inclusive implementation, follow-up and review of the 2030 Agenda at all levels. We acknowledge the primary responsibilities of Governments in this regard. We also acknowledge the contribution of parliaments, subnational governments and all other relevant stakeholders, including the private sector, civil society, academia and philanthropic organizations. Their participation supports accountability to our citizens and enhances the effectiveness of our action, fostering synergies, multi-stakeholder partnerships and international cooperation, and the exchange of best practices and mutual learning. We welcome the participation and contributions

of major groups and other relevant stakeholders in the high-level political forum and encourage their continued engagement in ensuring that no one is left behind;

16. *Stress* that the availability and use of accessible, timely, reliable and high-quality disaggregated data underpins our efforts to leave no one behind by, inter alia, identifying inequalities. Such data should measure poverty in all its forms and dimensions as well as progress on sustainable development, to reveal inequalities, gaps, progress and recurrent challenges, identify innovative solutions and inform the implementation of the 2030 Agenda at all levels. We are committed to developing broader measures of progress to complement gross domestic product. We urge Governments and international organizations, including the United Nations system, international financial institutions and other relevant stakeholders, to assist developing countries in further building and strengthening capacities for data collection, disaggregation, dissemination and analysis at all levels, taking into account that the global review of the 2030 Agenda will be based primarily on national official data sources. We welcome the decision of the Statistical Commission on the global indicator framework for the Sustainable Development Goals and targets prepared by the Inter-Agency and Expert Group on Sustainable Development Goal Indicators, which is a practical starting point, and look forward to its implementation and continual improvement in an inclusive and transparent manner;

17. *Commend* the 22 countries[1] that presented voluntary national reviews at the 2016 high-level political forum, and highlight the commitment and leadership shown by these countries in their early steps to implement the 2030 Agenda, including by integrating it into their national development and sustainable development strategies. Country-led reviews at the national level should be the foundation for voluntary reviews at the regional and global levels, as appropriate. Consistent with the 2030 Agenda, such reviews can promote the inclusive participation of all relevant stakeholders in its implementation, fostering national and subnational ownership and thus enhancing our efforts to ensure that no one is left behind. We stress the importance of building national capacities for follow-up and review, and the usefulness of making assistance available for preparing for the national voluntary reviews at the high-level political forum, including through voluntary guidance and methodologies to address issues such as the interlinkages among the Sustainable Development Goals. We encourage countries to take into consideration experience gained and lessons learned from these 22 State-led voluntary reviews, and to volunteer in the coming years;

18. *Recognize* the important role that regional and subregional forums can have in supporting the implementation of the 2030 Agenda, including its follow-up and review process, by, inter alia, promoting peer learning and cooperation, including South-South and triangular cooperation as appropriate, and helping to link the national and global levels of implementation. In this regard, we welcome the identification, development and convening of appropriate regional and subregional forums on sustainable development;

19. *Stress* that reducing vulnerability to climate change is a global challenge faced by all, in particular those living in poverty. We recognize the synergies of the Paris Agreement with the 2030 Agenda for Sustainable Development. We welcome the Paris Agreement, under which all parties will take urgent action to address climate change, and in that regard look forward to its prompt ratification, acceptance, approval or accession and its early entry into force and implementation. We also look forward to the mobilization of resources to assist its implementation. We recognize the specific needs and special circumstances of developing countries, especially those that are particularly vulnerable to the adverse effects of climate change;[2]

20. *Reiterate* that each country faces specific challenges in its pursuit of sustainable development. The most vulnerable countries and, in particular, African countries, least developed countries, landlocked developing countries and small island developing States deserve special attention, as do countries in conflict and post-conflict situations. There are also serious challenges within many middle-income countries. In this regard, we welcome the progress made to date and reaffirm support for the Istanbul Programme of Action for the Least Developed Countries for the Decade 2011-2020, the SIDS Accelerated Modalities of Action (SAMOA Pathway) and the Vienna Programme of Action for Landlocked Developing Countries for the Decade 2014-2024, and reaffirm the importance of supporting the African Union's Agenda 2063 and the programme of the New Partnership for Africa's Development, to ensure that no one is left behind. We also take note of the principles set out in the New Deal for Engagement in Fragile States by the Group of Seven Plus, countries that are, or have been, affected by conflict;

21. *Look forward* to all ongoing and upcoming intergovernmental processes which will contribute to the implementation of the 2030 Agenda, including, inter alia, the United Nations Conference on Housing and Sustainable

1 China, Colombia, Egypt, Estonia, Finland, France, Georgia, Germany, Madagascar, Mexico, Montenegro, Morocco, Norway, Philippines, Republic of Korea, Samoa, Sierra Leone, Switzerland, Togo, Turkey, Uganda and Venezuela (Bolivarian Republic of).

2 As provided for in the United Nations Framework Convention on Climate Change.

Urban Development (Habitat III), to be held in Quito in October 2016; the United Nations high-level plenary meeting on addressing large movements of refugees and migrants, to be held in New York in September 2016; the thirteenth meeting of the Conference of the Parties of the Convention on Biological Diversity, to be held in Cancun, Mexico, in December 2016; and the Group of 20 Summit to be held in Hangzhou, China, in September 2016. We recommend that these processes and other efforts, including, inter alia, the Sendai Framework for Disaster Risk Reduction 2015-2030 and the 10year Framework of Programmes on Sustainable Consumption and Production Patterns, should focus on ensuring that no one is left behind. We stress the importance of system-wide strategic planning, implementation and reporting in order to ensure coherent and integrated support for the effective implementation of the 2030 Agenda by the United Nations development system, taking into account its integrated and indivisible nature;

22. *Endorse* the outcome of the process of consultation on the scope, methodology and frequency of the Global Sustainable Development Report as well as its relationship with the Sustainable Development Goals progress report, as laid out in the annex to the present declaration;

23. *Are encouraged*, despite varied new challenges emerging after the adoption of the 2030 Agenda, by the enthusiasm, innovation and dedication of the wide array of actors already engaged, in collaborative partnerships, in its implementation, showing that this is an Agenda of the peoples, by the peoples and for the peoples. In this regard, we look forward to its continued inclusive implementation and urge that every effort be made to reach the furthest behind first and to ensure that no one is left behind.

43rd plenary meeting
22 July 2016

Annex

Global Sustainable Development Report: scope, frequency, methodology and relationship with the Sustainable Development Goals progress report

We, the Ministers and high representatives, having met at United Nations Headquarters in New York,

Scope

Recalling paragraph 83 of the 2030 Agenda for Sustainable Development,

1. *Stress* that the Global Sustainable Development Report is one important component of the follow-up and review process for the 2030 Agenda for Sustainable Development;

2. *Also stress* that the Global Sustainable Development Report will inform the high-level political forum, and shall strengthen the science-policy interface and provide a strong evidence-based instrument to support policymakers in promoting poverty eradication and sustainable development. It will be available for a wide range of stakeholders, including business and civil society as well as the wider public;

3. *Resolve* that the Report should incorporate scientific evidence in a multidisciplinary manner, considering all three dimensions of sustainable development, in order to reflect the universal, indivisible and integrated nature of the 2030 Agenda. With its universal scope, the Report should also consider the regional dimension, as well as countries in special situations. The Report will provide guidance on the state of global sustainable development from a scientific perspective, which will help address the implementation of the 2030 Agenda, provide lessons learned, while focusing on challenges, address new and emerging issues, and highlight emerging trends and actions. The Report should also focus on an integrated approach and examine policy options with a view to sustaining the balance between the three dimensions of sustainable development. These policy options should be in line with the 2030 Agenda to inform its implementation;

Frequency

4. *Resolve* that a comprehensive, in-depth Report will be produced every four years to inform the high-level political forum convened under the auspices of the General Assembly;

5. *Also resolve* that each year, in order to strengthen the science-policy interface at the high-level political forum convened under the auspices of the Economic and Social Council, scientists who work on the Report should be invited to provide scientific input into the discussion, including on the theme of the forum;

Methodology

6. *Stress* that the main principles guiding the methodology of the Report should be objectivity, independence, transparency, inclusiveness, diversity, scientific excellence and integrity, and policy relevance. The Report represents the result of an ongoing dialogue among scientists in all relevant fields on sustainable development worldwide, ensuring geographically balanced participation and assessing existing assessments, including the relevant reports on sustainable development from a variety of sources, including the United Nations system, as well as bringing together dispersed information;

7. *Request*, therefore, the creation of an independent group of scientists to draft the quadrennial Global Sustainable Development Report. The independent group of scientists is to comprise 15 experts representing a variety of backgrounds, scientific disciplines and institutions, ensuring geographical and gender balance. The group will be appointed for each Global Sustainable Development Report by the Secretary-General in open, transparent and inclusive consultations with Member States, including the possibility of taking nominations from Member States. The group will commence its work by the end of 2016. It will be supported by a task team, co-chaired by one representative each of the United Nations Secretariat, the United Nations Educational, Scientific and Cultural Organization, the United Nations Environment Programme, the United Nations Development Programme, the United Nations Conference on Trade and Development and the World Bank, with the logistical support of the United Nations Secretariat. The task team will coordinate inputs from a network of existing networks, representing the United Nations, the private sector, civil society and academia. Inputs can also be posted onto the high-level political forum online platform annually;

Relationship with the Sustainable Development Goals progress report

8. *Acknowledge* the distinct but complementary nature of the Sustainable Development Goals progress report and the Global Sustainable Development Report, both contributing to the high-level political forum from different perspectives. The high-level political forum will be informed by the annual Sustainable Development Goals progress report, which is to be prepared by the Secretary-General in cooperation with the United Nations system, on the basis of the global indicator framework, data produced by national statistical systems and information collected at the regional level. The Global Sustainable Development Report will be more scientific and analytical, focused on the science-policy interface, and will also inform the high-level political forum.

Annex II

Annex II

Acknowledgments

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**

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Annex III

Annex III

Review process

The review of the 2019 Global Sustainable Development Report was coordinated by the Department of Economic and Social Affairs of the United Nations (UNDESA), in collaboration with the International Science Council (ISC), the InterAcademy Partnership (IAP) and the World Federation of Engineering Organizations (WFEO).

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Annex IV

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